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Mineral Resource Report 80

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GEOLOGY AND MINERALOGY OF COPPER-URANIUM OCCURRENCES IN THE PICTURE ROCKS AND SONESTOWN QUADRANGLES, LYCOMING AND SULLIVAN COUNTIES, PENNSYLVANIA

Robert C. Smith, II
Donald T. Hoff

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COMMONWEALTH OF PENNSYLVANIA
DEPARTMENT OF ENVIRONMENTAL RESOURCES
OFFICE OF RESOURCES MANAGEMENT
BUREAU OF
TOPOGRAPHIC AND GEOLOGIC SURVEY
Arthur A. Socolow, State Geologist

Mineral Resource Report 80

GEOLOGY AND MINERALOGY OF COPPER-URANIUM OCCURRENCES IN THE PICTURE ROCKS AND SONESTOWN QUADRANGLES, LYCOMING AND SULLIVAN COUNTIES, PENNSYLVANIA

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Pennsylvania Historical and Museum Commission

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PREFACE

This report documents a large number of copper and uranium occurrences within one area of the Catskill Formation in northeastern Pennsylvania, and should assist exploration geologists and prospectors in evaluating the potential for minable deposits within and beyond Lycoming and Sullivan Counties. Surface mineralization occurs in only a very small percentage of the study area. The locations provided should assist planners in coordinating future recreational, forestry, agricultural, and other projects.

Because this scenic area is endowed with a relatively large number of unusual mineral species, the report will be of interest to both mineral collectors and professional mineralogists. With the descriptions and illustrations provided herein, even those unable to travel to the area should be able to appreciate these remarkable minerals. Similarly, the area provides amateur and professional geologists with excellent exposures of Catskill Formation sedimentary rocks for outdoor learning experiences as well as scientific research.

ACKNOWLEDGEMENTS

The authors gratefully acknowledge the encouragement of the Director of the Pennsylvania Geological Survey, Dr. Arthur A. Socolow, who has had a long-standing interest in the mineral occurrences of the Beaver Lake area. The Director's continued support as the project expanded to include analyses and descriptions of newly found occurrences is thoroughly appreciated.

Several former uranium prospectors of the late-1950's boom have disclosed locations for the present study. The most notable and versatile of these, John V. Jordan, provided the locations of five previously unknown occurrences. In addition, Wilbur Mills, Paul Taylor, Anthony Gill, and Ernest Edkin each provided information leading to the location or relocation of occurrences. Other local residents, not involved in prospecting, who provided information leading to the relocation of old prospects include Cleon Myers, the Charles Hill family, Tom Watkins, Gary Kraft, Jim Fought, Bob Marquardt, and Bob Shultz. Individuals in the mineral exploration industry in Denver and Toronto kindly assisted in the relocating of the McCauley 22 prospect and the locating of the Bench Mark 359 and Middle Catskill Reduced Zone occurrences for the 43rd Field Conference of Pennsylvania Geologists. The permission of the many landowners to enter their private property for this study is also appreciated.

Capable field assistance during the summer of 1979 was provided by Robin B. Koeberle. Smith's field expenses were paid by the Pennsylvania Geological Survey and Hoff's by the William Penn Memorial Museum. The Bendix Field Engineering Corporation's Pittsburgh District provided most of the uranium and semiquantitative trace-element analyses of the channel samples cut by the authors for this project.

Because of the extensive cooperation between the Pennsylvania Geological Survey, the Pennsylvania State University, and the William Penn Memorial Museum for the 43rd Field Conference, a moderate amount of cross-pollenization of concepts occurred prior to the writing of this report. It is therefore likely that some unreferenced information from W. D. Sevon, A. W. Rose, and the latter's student, A. T. Smith, is included in this report.

The excellent microcrystal photomicrographs were provided by the late Colonel T. Myers, and the polished-section photomicrographs by J. H. Barnes of the Survey. Albert Mehring, of the William Penn Memorial Museum, provided professional assistance in identifying plant specimens from the Old Copper open pit geobotanical anomaly.

Reviews of this manuscript have been graciously provided by J. H. Barnes, Arthur Montgomery, A. W. Rose, and A. A. Socolow. Geologic contacts on Plate 1 are from reconnaissance mapping by W. D. Sevon and T. M. Berg for the 1980 state geologic map (Berg and others, 1980).

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A. A. Socolow (left), Director of the Pennsylvania Geological Survey, on the 43rd Field Conference of Pennsylvania Geologists.

A. T. Smith, R. C. Smith, and D. T. Hoff (facing left to right) at McCauley prospect 28 during the 43rd Field Conference.

GEOLOGY AND MINERALOGY OF COPPER-URANIUM OCCURRENCES IN THE PICTURE ROCKS AND SONESTOWN QUADRANGLES, LYCOMING AND SULLIVAN COUNTIES, PENNSYLVANIA

by

Robert C. Smith, II, and Donald T. Hoff

ABSTRACT

Approximately 50 small red-bed copper-uranium occurrences in the Picture Rocks and Sonestown quadrangles have been located, sampled, and described. The area was prospected for copper during the mid-nineteenth and early twentieth centuries and for uranium during the late 1950's and 1970's.

The occurrences are located in the Upper Devonian Catskill Formation, an approximately 1,100 m (3,600 ft) thick sequence composed predominantly of grayish-red (5R4/2) sandstones, siltstones, and shales deposited in a predominantly meandering-river environment. The rocks are composed of quartz, muscovite, chlorite, albite, and locally calcite. Most mineralized occurrences are associated with carbonaceous plant trash in the reduced base of fining-upward fluvial cycles. The calcareous "breccias" (lag gravels) at the base of such cycles contain phosphatic fossil fish (freshwater crossopterygian and placoderm) remains and have a median U_3O_8 content of 34 ppm (parts per million) and a median copper content of 4,150 ppm. The overlying gray (reduced) sandstones have a median U_3O_8 content of 55 ppm and a median copper content of 2,400 ppm. Associated reduced siltstones and shales have median contents of 39 ppm U_3O_8 and 3,000 ppm copper. The median lead content is highest in sandstones (215 ppm), and arsenic may decrease with grain size. A few occurrences are enriched in vanadium, molybdenum, silver, and barium, whereas zinc is conspicuous by its absence. A typical "good" occurrence is estimated to contain only 14 kg (30 lb) U_3O_8, 700 kg (1,500 lb) copper, and 2 kg (60 troy oz) silver.

The apparent order of deposition for copper minerals is bornite, digenite, chalcocite/djurleite and galena, and tennantite. Uraninite has been identified at only two occurrences and may not be primary.

Major secondary copper minerals include malachite, azurite, chrysocolla, and brochantite, in approximate order of decreasing abundance. Minor secondary uranium minerals include kasolite, metatorbernite, metazeunerite, and uranophane. Other verified minerals include anglesite, arsenopyrite, barite, beta-uranophane, cerussite, chalcophyllite, chalcopyrite, covellite, cuprosklodowskite, francevillite, idaite, langite, a so-far-unidentified linarite-like mineral, olivenite, posnjakite, pyrite, tyrolite, tyuyamunite, widenmannite, wulfenite, and zeunerite.

Copper-uranium occurrences in the Catskill Formation tend to be clustered both laterally and vertically. Lateral clustering includes (1) large, regional clusters such as the Beaver Lake district, described in this report, and the Central, New Albany, Carbon County, and Huntingdon County districts (Rose, A. W., 1970, *Metal mines and occurrences in Pennsylvania*, Pennsylvania Geological Survey, 4th ser., Mineral Resource Report 50, Part 3, 14 p.); and (2) small, local clusters, as, for example, around Sonestown Nose (Plate 1). Vertical clustering is a local effect resulting from exposures of favorable horizons that tend to follow contours in this area of subhorizontal bedding and possibly upward migration of more permeable depositional input channels.

Within the Beaver Lake district, vertical variation in the content of metallic elements in mineralized rock is greater than lateral variation. Small copper-uranium occurrences containing minor arsenic are most numerous in the relatively fine grained lower Catskill Formation. A few slightly larger occurrences containing minor lead in sandstones of the upper Catskill have greater economic significance. The former occurrences are believed to have been developed in short-lived, isolated postdepositional systems in which there was local derivation of ore and transport solutions from the compacting sediments. The few occurrences in the coarser grained upper Catskill may have been open to solutions from more distant sources and/or for longer periods.

Further commercial exploration for copper-uranium in the lower two thirds of the Catskill Formation does not appear promising in this area. Mapping of the coarser grained, reduced channels in the upper Catskill in conjunction with trace-element analyses for copper, uranium, arsenic, molybdenum, lead, selenium, and vanadium might aid in locating larger, partly remobilized occurrences. The Old/New U.S. 220 cluster (505 ± 320 ppm U_3O_8) has the highest mean U_3O_8 content of all of the clusters.

INTRODUCTION

LOCATION AND SETTING OF THE PICTURE ROCKS-SONESTOWN AREA

The project area includes the Picture Rocks and Sonestown 7-1/2-minute quadrangles in southeastern Lycoming and southwestern Sullivan Counties (Figure 1 and Plate 1). The Allegheny Front, which passes through the northern part of the area, separates the Allegheny High Plateaus section of the Appalachian Plateaus physiographic province from the Appalachian Mountain section of the Valley and Ridge physiographic province (Figure 2). Most of the observed mineralization occurs to the south of the Allegheny Front.

The elevations in the mineralized portions of the project area range from about 215 to 450 m (700 to 1,500 ft). The primary drainage is to the southwest via Muncy Creek, and the main highway, U.S. Route 220, follows the

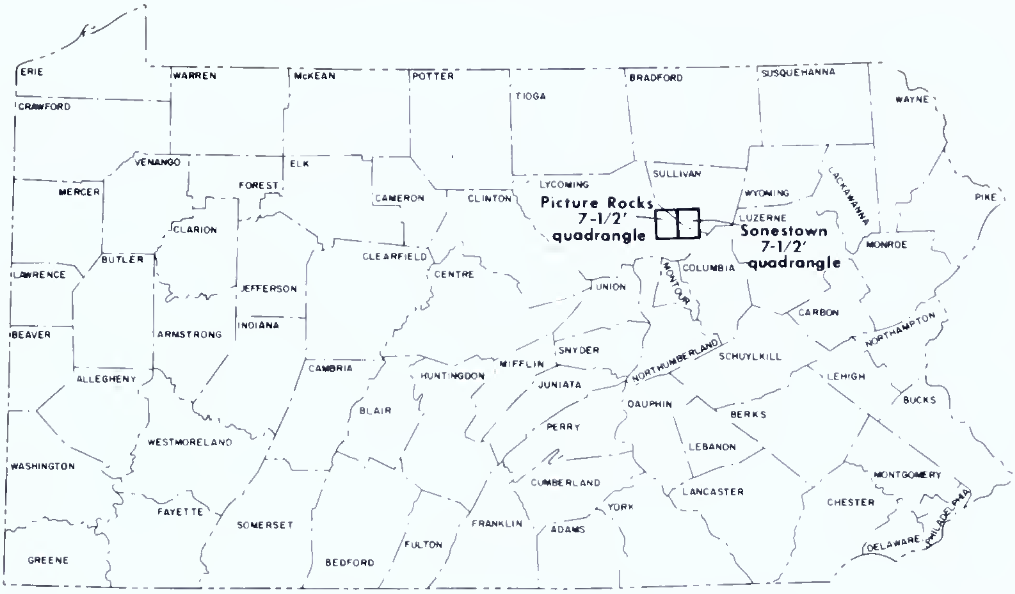

Figure 1. Location of the project area with respect to county and state boundaries.

valley of that creek. Except for Muncy Creek valley, the area is thinly populated, and individual properties are commonly a few hundred acres.

Glacial till of the Wisconsinan terminal moraine occurs discontinuously in a semicircle within the southern half of the project area (Crowl and Sevon, 1980). The till-covered areas are underlain by shales of the Trimmers

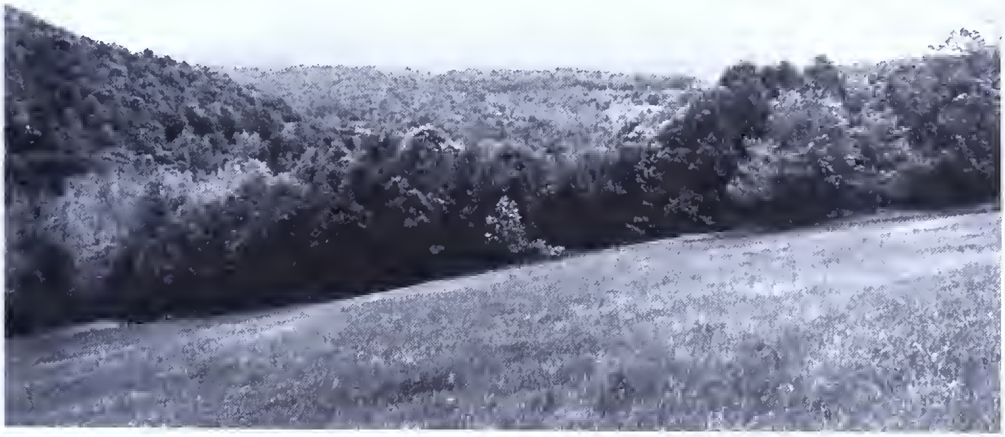

Figure 2. View of North Mountain in the distance, looking northeast from near Jason Montague's home in Strawbridge. North Mountain is part of the Allegheny High Plateaus section and the foreground is part of the Appalachian Mountain section.

Rock Formation and basal Catskill Formation, which are unfavorable for copper-uranium mineralization. Muncy Creek valley is filled with glaciofluvial sediments. Exposures on the steeper slopes north of the glacial border deposits are good, and soils are thin in such areas. Elsewhere, exposures are poor.

HISTORY OF COPPER AND URANIUM PROSPECTING IN THE PICTURE ROCKS-SONESTOWN AREA

Streby and Streby (1903, p. 4) mentioned in their report a group of Massachusetts promoters who opened a copper "vein" at Beaver Dam (now Beaver Lake) in 1848, and transported the ore to Boston. They also reported the reopening of this "vein" around 1903. They described Beaver Dam as a pretty, artificial lake situated across the Lycoming-Sullivan County boundary, mentioned A. L. Sones' hotel at Beaver Dam, and reported considerable progress towards developing copper ore in the vicinity by a copper mining company (Streby and Streby, 1903, p. 21).

Cora Sones (personal communication, December 10, 1981) reported that there was copper mining activity in the Beaver Dam area in about 1902 when she was 14 years old. She stated that the miners probably lived in a wooden shanty that was situated near the lake's outlet and the main Beaver Run road. Cora Sones' knowledge of the miners' activity is limited to Klemic locality 8, and she never personally observed the mining.

Cora Sones reported that her now-deceased father-in-law, Augusta L. Sones, opened his hotel at Beaver Dam in 1897 and that Beaver Dam was later renamed Beaver Lake when a post office was established at this locality. She recently examined the old Beaver Lake Hotel registry and found no evidence that copper miners boarded there. A. L. Sones sold the hotel in about 1918, and it burned to the ground in 1927.

The retrospective column of the Williamsport *Sun-Gazette* (January 16, 1967) mentioned an event of 65 years ago as follows: "The Beaver Lake Copper Smelting Company is prepared to take samples from ore deposits in Penn Township and send them to Boston. It is planned to reopen the mines which operated briefly and unprofitably in 1848." The Bloomsburg *Morning Press* (December 17, 1902, p. 5) noted the Beaver Lake Copper Company's accomplishment in locating their largest and richest "vein" of copper, and mentioned that a group of men had started mining the new discovery. An advertisement by Dent and Sharpless, First National Bank Building, in the Bloomsburg *Morning Press* (March 2, 1903, p. 5) offered Beaver Lake Copper Company stock at $0.40 per share, when the company's market price was listed at $1.00 per share.

Cleon Myers (personal communication, December 10, 1981) reported that copper mining activities in Copper Hollow, centered 1.1 km (0.7 mi) southwest of the Beaver Lake outlet (Plate 1), occurred very early in the twentieth century, and that there was possibly activity in the middle nineteenth century. Myers remembers when the firebricks (Figure 3) of Copper Hollow's former copper smelter were torn out, leaving only a clapboard roof on posts remaining in place. One side of the smelter's roof burned off in about 1913. A complete firebrick noted during the present study bore the

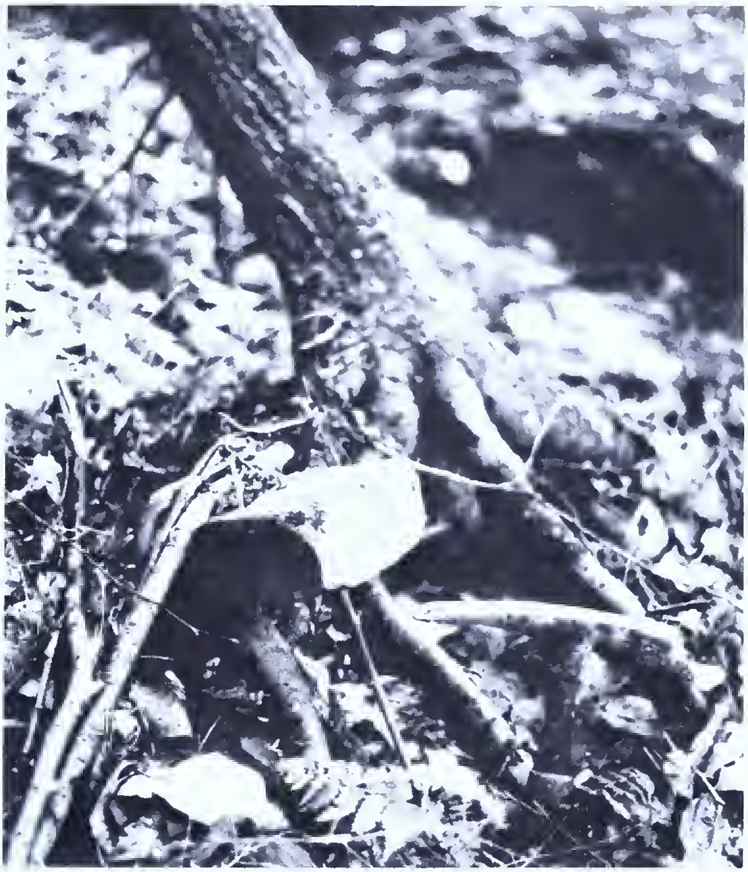

Figure 3. Firebrick (in tree roots) from the former copper smelter, dump pile east of Copper Hollow 5 prospect.

imprint "QUEENS RUN" and a fragment bore "CLINT. . . ." Platt (1880, p. 158-164) mentioned a Queen's Run Firebrick Works near Lock Haven, Clinton County. The blacksmith shop, formerly situated on the flat south of the smelter, was moved out of the hollow between 1906 and 1910. The shop building was placed on Monroe Snyder's farm on top of Barrett Hill (incorrectly labelled "Bad Hill" on the Sonestown 7-1/2-minute quadrangle map), and the forge and anvil were transported to Beaver Lake near the hotel.

Cleon Myers also remembered an interesting event that occurred when his uncle, Monroe Snyder, was commissioned by the copper mining company to haul a load of copper ore to Bloomsburg, Pennsylvania, for a stock-promotion stunt. In Bloomsburg, the promoters placed the wagon load of ore near a miniature, fabricated copper mine complete with mine cars on railroad tracks.

James McClain (personal communication, December 31, 1981) reported that his father, H. Curtis McClain, investigated the history of copper prospecting on the McClain estate near Strawbridge. Following his investigations, the elder McClain thought the mining activity on his property probably occurred prior to the 1860's.

Arnold M. Fox (personal communication, December 5, 1981) reported that the copper adit of McCauley prospect 24 was excavated in the 1880–82 period by his uncle, William Coleman Hall, and two additional men. The adit required more than one year to develop and was funded by two Philadelphia men interested in copper occurrences.

Prospecting for metalliferous ores in the Picture Rocks-Sonestown area apparently remained dormant from the time of the copper prospecting in the early twentieth century until the uranium excitement in the middle to late 1950's. The greatest effort towards the development of a profitable uranium mine at one locality (Sonestown Nose uranium trench of Gill-Jordan) was made by the Gill Mining Corporation (Figure 4). Anthony Z. Gill (personal communication, March 10, 1980) reported that he discovered this occurrence in about 1957. A promotional circular (1958) stated that the Gill Mining Corporation was organized on October 6, 1958, and was conducting uranium exploration at the Sonestown site. The circular listed Anthony Z. Gill as president, director, and dominant stockholder, and John V. Jordan as vice-president and director. The first uranium-copper occurrence found by Gill is in the glen along Mosey Run (see "Mosey Glen uranium-copper occurrence," p. 160, and Plate 1). Later, after Gill moved to Colorado, Jordan became president and John Fredock became vice-president.

During the middle to late 1950's, there was additional uranium exploration in the Picture Rocks-Sonestown area. John V. Jordan (personal communication), acting independently of the Gill Mining Corporation, discovered and excavated Jordan North Mountain uranium prospects 1 and 2, and also Klemic locality 12, southwest and northeast sites. John V. Jordan (personal communication, June 29, 1979) discovered the Hamilton-Jordan copper-uranium prospect while constructing a road for Elmer Hamilton of

Figure 4. J. Fredock, A. Gill, and J. Jordan in the Sonestown Nose uranium trench of Gill-Jordan as it appeared overgrown on March 10, 1980.

Hughesville, Pennsylvania. Hamilton then fabricated a smelter of steel in his Hughesville welding shop to smelt copper ore from Jordan's discovery. The Hamilton smelter now rests adjacent to the abandoned Jordan sawmill near Beaver Lake (Figure 5).

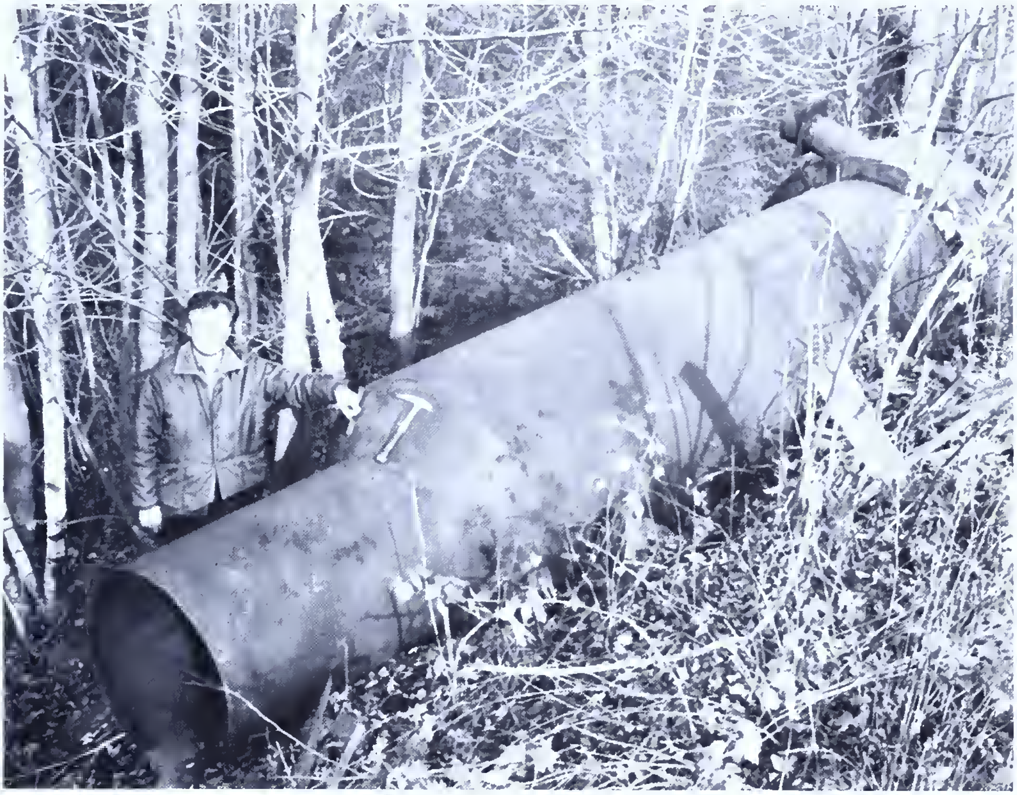

Figure 5. Copper smelter fabricated of steel by Elmer Hamilton of Hughesville to process samples from the Hamilton-Jordan copper-uranium prospect. The smelter is presently located adjacent to the abandoned Jordan sawmill site.

Wilbur Mills (personal communication, June 20, 1979) rediscovered McCauley prospect 22 by first observing the old northwest adit, and then finding the relatively extensive uraniferous zone to the southeast. Mills' discovery was prospected by the unofficial "Agony Hill Mining Company," comprised of Wilbur Mills, Paul Taylor, Raymond Houseknecht, and Robert Artley. The southeast adit of McCauley prospect 22 stands as the most obvious monument to their efforts.

The Highland Exploration and Mining Company, Inc., which issued its first stock on January 26, 1957, excavated McCauley prospect 23 and the Fort Sumpter uranium prospect, and blasted out around 3 tons of mineralized rock 3.5 m (11 ft) south of the center of the older McCauley prospect 24 copper adit. Paul Taylor was the president and Eugene Sones was the secretary of the company.

Donald Avery (personal communication, February 10, 1980) discovered McCauley prospect 18 (Klemic locality 11) in company with his brother, Emmitt Avery, in July 1955. The Averys formed a corporation for mining and further exploration purposes in October 1955. The major removal of mineralized rock from the adit occurred from March 1956 through the summer of 1956. Mining in the adit continued through 1957 and exploratory drilling through 1958.

Mrs. Leon Myers, Jr. (personal communication, June 28, 1978), reported that McCauley prospect 21 was examined in 1955 by Calvin J. Wagner of Vienna, Virginia, and Edward Kadidlo of College Park, Maryland. Wagner, Kadidlo, and their assignees renewed their lease on July 24, 1956.

David Weston (personal communication, January 4, 1982) reported that McCauley prospect 17 was prospected by the Allegheny Mining Company, Inc. Chester Temple, now deceased and formerly of the Lock Haven area, was the president of this corporation, which was composed of seven members.

The above-named uranium prospectors and corporation officials were all residents of the Picture Rocks-Sonestown area, unless noted otherwise. A. Z. Gill now resides in Lebanon, Pennsylvania.

GEOLOGY OF THE PICTURE ROCKS-SONESTOWN AREA

The host rock for the observed copper-uranium occurrences in the project area is the Upper Devonian Catskill Formation. In the project area, the Catskill Formation is about 1,070 m (3,500 ft) thick (Sevon and others, 1978) and is composed predominantly of reddish-gray shales and siltstones. A summary of the stratigraphic sequence is presented in Table 1. The Catskill Formation is relatively well exposed along U.S. Route 220 between Tivoli and Laporte, the latter being just northeast of the project area. Traditionally, this formation has been interpreted as having been deposited in a complex alluvial-fan system. This concept was summarized by Sevon and others (1978, p. 5–9 and 22). More recently, Rahmanian (1979) and A. T. Smith (1980) emphasized the importance of thin marine transgressions.

The base of the Catskill Formation is transitional with the underlying Devonian Trimmers Rock Formation, a sequence of fossiliferous, dark-gray marine shales and siltstones. Mahar (1978) mapped a thin marine-transgression unit into the lowermost Catskill in the area from south of Tivoli to Beaver Lake. Others are probably present, such as perhaps at Biggerstown in the southeast corner of the Sonestown quadrangle. Although the Trimmers Rock Formation may have been a source for some of the later introduced base metals in the Catskill Formation, the former does not appear to have good potential as an ore host.

The Catskill Formation is overlain by the newly defined Huntley Mountain Formation, a rock-stratigraphic unit of Late Devonian-Early Mississippian age composed mainly of gray sandstones (Berg and Edmunds, 1979). Although significant amounts of copper and uranium are not known to oc-

Table 1. *Stratigraphic Sequence of the Catskill Formation in the Sonestown Area*

The section description is based on an abstract by Sevon and others (1978) of the Geolog of No. 1, A. Bennett well, drilled by The California Company in 1951 at 41°21′00″N/ 76°30′58″W, about 3.3 km (2.0 mi) east of Sonestown, Sonestown quadrangle. The top of the section is about 200 m (650 ft) below the top of the Catskill. The total thickness of the Catskill Formation in the area is about 1,070 m (3,500 ft).

Formation	Major unit	Description	Thickness (m)	Thickness (ft)
Catskill	F	Sandstone, red, very fine to fine-grained, micaceous, calcareous; contains red shale interbeds	21.3	70
		Siltstone, light-gray, argillaceous, micaceous; contains light-gray shale stringers	4.6	15
		Sandstone, red, very fine to fine-grained, micaceous, calcareous; contains calcareous nodules and stringers of siltstone and shale	41.1	135
		Sandstone, very light gray, very fine grained, micaceous, slightly calcareous	6.1	20
		Sandstone, red, very fine to fine-grained, argillaceous, micaceous, calcareous; contains red shale interbeds	56.4	185
		Shale, red, micaceous, calcareous; contains red siltstone stringers	19.8	65
		Sandstone, red, very fine grained, argillaceous, micaceous, calcareous	15.2	50
	E	Siltstone, red, argillaceous, micaceous, calcareous; contains red shale interbeds	42.7	140
		Siltstone, red, argillaceous, micaceous, calcareous; contains stringers of greenish-gray and red sandstone and shale	12.2	40
		Siltstone, red, sandy, micaceous, calcareous; contains red shale stringers	131.1	430
	D	Shale, green, silty, micaceous; contains interbeds of grayish-green, micaceous, calcareous siltstone	12.2	40
		Siltstone and sandstone, interbedded, grayish-green, calcareous, slightly micaceous; contains interbeds of red calcareous shale	39.6	130
	C	Siltstone, red, argillaceous, micaceous, calcareous; contains red shale stringers and interbeds	79.2	260
	B	Siltstone and shale, interbedded, grayish-green and red.	30.5	100
		Sandstone, grayish-green, very fine grained, silty, calcareous; contains siltstone stringers	9.1	30
		Shale, red, silty, micaceous; contains stringers of red, argillaceous, micaceous, calcareous siltstone	12.2	40
		Siltstone, gray, argillaceous, micaceous, slightly calcareous; contains interbeds of gray, slightly micaceous, calcareous sandstone	51.8	170

Table 1. *(Continued)*

Formation	Major unit	Description	Thickness	
			(m)	(ft)
Catskill	A	Shale, red, silty, micaceous, slightly calcareous	12.2	40
		Shale, green, silty, micaceous; contains stringers of grayish-green sandstone and siltstone	9.1	30
		Shale, red, silty, micaceous, slightly calcareous; contains stringers of sandstone and siltstone	21.3	70
		Shale, green, silty, micaceous; contains interbeds of green siltstone and red sandstone	12.2	40
		Shale, red, silty, micaceous, interbedded with red, argillaceous, micaceous, slightly calcareous siltstone	30.5	100
		Siltstone, grayish-green, slightly argillaceous, slightly micaceous, calcareous	9.1	30
		Sandstone, red, very fine grained, silty, slightly calcareous, interbedded with red siltstone; contains shale stringers	16.8	55
		Sandstone, grayish-green, very fine grained, slightly micaceous, calcareous	6.1	20
		Sandstone, red, very fine grained, micaceous	3.0	10
		Shale, green, silty, micaceous; contains stringers of grayish-green, micaceous, calcareous sandstone and siltstone	7.6	25
		Sandstone, grayish-green, silty, slightly micaceous, calcareous; contains stringers of green shale and interbeds of red siltstone and shale	21.3	70
Lock Haven (= Trimmers Rock)	B	Sandstone, gray to grayish-green, very fine grained, silty, slightly micaceous, slightly calcareous; contains green shale stringers	57.9	190
		Shale, greenish-gray, silty	6.1	20
		Sandstone, greenish-gray, very fine grained, silty, slightly micaceous, calcareous; contains stringers of green shale and interbedded sandstone, siltstone, and shale at the base	70.1	230
	A	Siltstone and shale, interbedded, greenish-gray; several hundred meters thick		

cur in the Huntley Mountain Formation, its dominantly nonmarine character, coarse grain size, and position with respect to the mineralized Catskill Formation suggest that it should not be ruled out as an exploration target.

Detailed 1:24,000 geologic maps of the Catskill Formation in the area are not available. Except for mapping the marine-transgression units and the larger reduced channel sands near the top, generation of a useful map at such a scale would be difficult. Practical subdivisions, suitable for detailed mapping from float, have not yet been identified for the area. Crossbedding and lensoidal bed forms present obvious problems in projecting potential markers.

Geologic contacts obtained via aerial-photograph interpretation and field reconnaissance by W. D. Sevon and T. M. Berg for the 1980 state geologic map (Berg and others, 1980) are included on Plate 1.

Except in the area in the western part of the Picture Rocks quadrangle that is apparently barren of copper-uranium mineralization, bedding typically dips less than 10 degrees. In general, bedding in the vicinity of most of the occurrences dips 5 ± 2 °N (Plate 1). Sudden dip variations in the western portion of the Picture Rocks quadrangle suggest the possibility of faulting or minor kink-band folding in that area. No other evidence of moderate deformation was observed.

The most prominent joints trend about N30° to 35°E and are subvertical. Joints do not appear to be related to copper mineralization and, to avoid cluttering Plate 1, are presented as a rose diagram (Figure 6) and are summarized in Table 2. One joint that has an azimuth of N39°E at Jordan North Mountain uranium prospect 1 is coated with barite. Additional joints containing barite were observed along new U.S. Route 220 about 20 m (65 ft) southwest of survey marker 3/20, along old U.S. Route 220 near the occurrence listed in Appendix 2, and in the "borrowed" roadcut just northeast of the Marquardt copper and uranium occurrences.

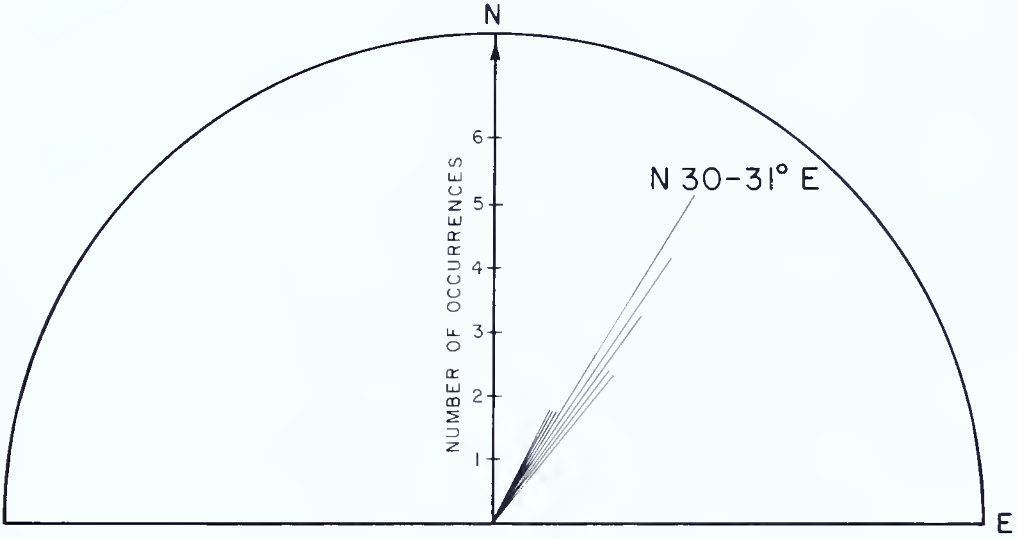

Figure 6. Rose diagram showing the orientation of prominent joints at 27 copper-uranium occurrences in the Picture Rocks and Sonestown quadrangles. The individual measurements, which represent medians of jointing at each occurrence, have been grouped in 2-degree intervals.

PREVIOUS AND CONTEMPORANEOUS STUDIES

Previous Studies

Weed (1911, p. 59–60) described the Carpenter mine near New Albany, Bradford County, about 25 km (16 mi) north-northeast of the project area.

Table 2. *Joint Data for Copper-Uranium Occurrences in the Picture Rocks and Sonestown Quadrangles*

Location	Joint orientation[1]
Allegheny Ridge copper-uranium occurrence	~N25°E
Copper Hollow 1 uranium-copper prospect	N38°E
Copper Hollow 3 uranium-copper prospect (McCauley prospect 20)	N31°E
Copper Hollow 4 prospect	N31°E
Copper Hollow 5A prospect	N37°E
Copper Hollow 6 prospect	N32°E
Copper Hollow 8 prospect (northwest adit)	N35°E
Copper Hollow 8 prospect (southeast adit)	N32°E, N35°E
Sonestown Nose uranium trench of Gill-Jordan	N24°E, N34°E
Hill Family Reduced Zone copper and uranium occurrences	N32°E
Jordan borrow pit	N30°E
Jordan North Mountain uranium prospect 1	N39°E (barite present)
Jordan Sawmill adits	N36°E
Klemic locality 8	N36°E, N38°E
McCauley prospect 22	N33°E (both northwest and southeast adits)
McCauley prospect 24	N23°E (Sevon and others, 1978)
McCauley prospect 26	N28°E
McCauley prospect 28-1/2 of Mahar	N26°E
McCauley prospect 18 (Avery Brothers uranium adit)	~N35°E
Rock Run uranium occurrence	N26°E
Shultz copper adit	N30°E
Strawbridge copper prospect 1	N31°E
Strawbridge uranium-copper lens	N30°E
Strawbridge Northwest uranium-copper lens	N28°E

[1] All measured joints are essentially vertical.

He noted that the copper ore occurred in a gray shale bed containing abundant lignite as branches and other plant remains. He also noted that the shale was underlain by a limestone conglomerate containing copper associated with fossil plant remains, and that it was overlain by red shale.

Butler (1938, p. 625-634) described two red-bed copper occurrences in the Catskill Formation near Forkston, Wyoming County, about 38 km (24 mi) northeast of the project area.[1] From examination of specimens, Butler observed that copper sulfides were preferentially localized with plant remains. He determined the volatile content of carbonaceous matter to be 13.5 percent, classifying it as a semianthracite according to present usage. This is consistent with his report that it was noncoking. Fossil plant fragments were determined to be elliptical in cross section, the axes having a 3:1 ratio.

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[1] White (1883, p. 129) mentioned, but did not describe, copper in the northern entrance of the D. L. and W. Railroad tunnel in Nicholson Township, Wyoming County, still farther from the project area.

Bornite and "white and blue chalcocite" were noted in about equal quantities, and chalcopyrite and covellite in very minor amounts. Butler concluded that compression and burial metamorphism occurred prior to introduction of cupriferous meteoric solutions and that there is no evidence of postmineralization deformation.

McCauley (1958) mentioned more than 40 copper-uranium prospects in the Catskill Formation in north-central Pennsylvania, but did not furnish locations. From descriptions in McCauley's 1961 report, in which there are locations for 34 Catskill occurrences in Pennsylvania, it is known that his 1958 discussion included the Picture Rocks and Sonestown quadrangles. McCauley (1958) reported the general paragenesis, from oldest to youngest, as pyrite, bornite and chalcopyrite, galena, digenite, barite, chalcopyrite, chalcocite, and covellite. He reported further that the chalcocite and covellite are supergene and that copper mineralization occurred after coalification had begun. His proximate analysis of the coaly material suggested to him a low-volatile bituminous coal. The coaly material is described as having well-developed joints and cleats with sulfide filling; in some cases, replacement of coaly material by sulfides occurs along these openings. He noted that cell structures are well preserved but that this is not indicative of mineralization before coalification.

McCauley's experimental heating of bornite for 2 weeks at 180°C enhanced preexisting exsolution lamellae of chalcopyrite. This was misinterpreted by him as suggesting a temperature of formation greater than or equal to 180°C (see the discussion of Gaucher (1959) below).

The Catskill Formation was broadly subdivided by McCauley (1958) into the following: (1) a 400-foot- (120-m-) thick upper sequence of gray to green sandy channel deposits containing only minor red interbeds. Carbonaceous material containing pyrite but no copper or uranium was reported. This pyrite was said to occur in a thin black shale lens, and was interpreted as being either syngenetic or diagenetic; (2) a 1,000-foot- (300-m-) thick middle sequence of red shale and mudstone containing a few thin gray to green channel deposits; (3) an 800-foot- (240-m-) thick lower sequence of gray to green channel deposits and red mudstones and shales in a complex, overlapping network that is transitional to the underlying Devonian marine rocks. He noted that carbonaceous material is abundant in the reduced units and that all mineralization is restricted stratigraphically to this lowest 800 feet (240 m) (see Plate 1 for comparison). He deduced that ascending hydrothermal solutions were restricted by the proposed impermeable middle shale layer. This was apparently based on his observation of the distribution of minerals.

Gaucher (1959) reinterpreted McCauley's (1958) bornite heating experiment. He reasoned that if heating to 180°C for 2 weeks had the effect of enhancing the exsolution lamellae of chalcopyrite, then the specimen was never exposed to such a high temperature for any geologically significant period of time in its natural environment. Thus, 180°C would be the extreme upper temperature limit for formation of the deposit.

Other observations by McCauley (1961) concerned deposit geometry, petrology, ore mineralogy, and bornite-chalcopyrite exsolution lamellae.

Mineralization was observed to be limited to conformable, thin, planar bodies that pinch out laterally within a few tens of feet. The thickest mineralized seam observed by McCauley consisted of several parallel stringers within a zone about 1 foot (0.3 m) thick, but this was outside the Picture Rocks-Sonestown project area.

He noted that the host rock consisted of subgraywacke that had a larger percentage of matrix (chlorite, muscovite, illite, and kaolinite) and more quartz recrystallization and welding in the actual uraniferous zones than in barren country rock. From thin-section study, McCauley (1961, p. 40) found that the red coloration of the graywacke versus gray and green coloration results from the presence of interstitial hematite. Those units that had negligible hematite were found to be gray or green depending on the amount of chlorite acting as a green coloring agent. In addition to the hypogene minerals he reported in 1958, McCauley also identified azurite, malachite, chrysocolla, metazeunerite, uranophane, and uranospinite from various occurrences in north-central Pennsylvania.

During polished-section study, McCauley observed that some sulfides preserve plant-cell structures and concluded that some sulfides replaced fusain. He also observed the development of sulfides along cleats or joints in vitrain and concluded that coalification of plant fragments had developed prior to the beginning of mineralization. He reported that a pyrite, digenite, chalcocite, covellite, and barite (in paragenetic sequence) assemblage is found in both the Beaver Lake (included in present study area) and New Albany districts (see ''Primary Minerals'' section, p. 33).

McCauley's pioneer report (1961, p. 17–51) included the first descriptions of the copper-uranium occurrences within the Picture Rocks and Sonestown quadrangles. His Appendix A summarizes the 13 occurrences (McCauley prospects 17 to 29) known to him in this area. Some of his location descriptions are unusable, perhaps, in part, because of the unavailability of 1:24,000 topographic maps of the area at the time.

Qualitative X-ray fluorescence scans (McCauley, 1961, Appendix B, Table 4, p. 71) of two samples from the Beaver Lake district (as defined by McCauley) indicated that arsenic and barium were enriched as well as copper and uranium.

McCauley (1961) noted that carbonaceous material consisted of (1) vitrain as hard, jet-black material that has a vitreous luster, well-developed joints, and conchoidal fracture; and (2) fusain as sooty black material, some of which preserves original plant textures. A volatile content of 22 percent was obtained for undescribed carbonaceous material from the Central district, about 10 km (6 mi) east of the present project area. He concluded, based in part on the scarcity of visible secondary mineralization, that the major portion of the uranium is associated with carbonaceous material. He was unable to find any primary uranium minerals and believed that the uranium was present as an amorphous oxide or as an organo-metallic compound or mixture disseminated finely throughout the carbonaceous material.

Following Gaucher's (1959) corrective criticism, McCauley (1961, p. 42–44) pursued the *minimum* temperature at which chalcopyrite exsolution from bornite could be enhanced. Based on exsolution developed in the laboratory at 75 °C in 2 hours, it seemed likely to McCauley that the deposits were never subjected to even this low temperature. Samples from McCauley prospect 12, Central district, yielded a S^{32}/S^{34} range of 22.64 ± 0.02 to 22.85 ± 0.02.

McCauley's observations suggested to him that mineralization could not have been strictly syngenetic since it must have postdated at least the onset of coalification. His genetic models depended heavily upon his belief that, in the vicinity of the Allegheny Front (including the present study area), mineralization is confined to the lower portion of the Catskill Formation. McCauley (1961, p. 49) did, however, modify that belief in saying "This may simply reflect insufficient prospecting along the steep, heavily wooded mountain slopes where the upper Catskill Formation crops out." He did not speculate on what effect deposits higher in the Catskill, such as those found in the present study, would have on his models.

Klemic (1962), unlike McCauley (1958, 1961), concentrated his efforts on the upper Catskill and Mauch Chunk-Pottsville-transition deposits in Carbon County. These were chosen for study because of their larger size and higher grade. Klemic and others' U.S. Geological Survey Bulletin 1138 (1963) remains the classic report on uranium in Carbon County. Klemic (1962), however, included tabulated summaries of eight occurrences in the Picture Rocks-Sonestown field area (Klemic localities 6 to 13, p. 277–278) as well as four similar occurrences in Bradford County, three in Columbia County, and several others. Except for Klemic localities 7 and 13, obliterated by road construction, the localities were all found by the present authors. Attempting to create an overview of all uranium occurrences in sedimentary rocks in Pennsylvania, Klemic (1962) sought features common to all types of deposits rather than to develop a model for the small copper-uranium occurrences in north-central Pennsylvania.

Table 3 of Klemic (1962, p. 272) lists chemical uranium and selenium analyses for two localities in the project area, both apparently since destroyed by minor road construction. A hand sample(?) of gray, micaceous sandstone from Klemic locality 7 contained 0.10 percent uranium and 3 to 4 ppm (parts per million) selenium. Another hand sample of gray, micaceous sandstone from Klemic locality 13 contained 0.24 percent uranium and 1 ppm selenium.

Slaughter (1970), under the direction of H. L. McKague, collected samples of Catskill Formation rocks at 35 stratigraphically controlled sites along a west-northwest-trending traverse at McCauley prospect 19. The sampling technique at each site was not discussed. The mean background copper content was found to be 19 ppm. A copper occurrence was found at a vaguely located site at the same stratigraphic level as McCauley prospect 19, but on the east side of Beaver Run. Figure 46 of Slaughter (1970, p. 42) suggests that the occurrence contains 800 to 4,500 ppm copper and is about 200 ± 30 m (650 ± 100 ft) east of where the traverse crosses Beaver Run. This may or may not be the occurrence located "one half a mile from one of McCauley's prospects" (Slaughter, 1970, p. 11).

Using X-ray-diffraction and thin-section techniques, Slaughter found that the color of the host rock depends on the presence or absence of hematite. The host is red where hematite and chlorite coexist, and green where hematite is absent. The green rocks were found to be low in ferric iron. FeO contents of 0.4 to 4.6 percent and total iron of 1.5 to 7.2 percent are reported. "Green" beds were reported to typically pinch out laterally rather than grade laterally into "red" beds (Slaughter, 1970, p. 13).

A zone of copper depletion surrounding some of the copper-uranium deposits is reported, but the sampling does not appear to have been adequate. Sulfide grains were reported to be typically less than 50 microns (p. 14). Although Slaughter reported that all of his reduced samples were "enriched" in copper, the results of the present study do not indicate that all such samples are "mineralized."

Humphreys and Friedman (1972, 1981) analyzed 300 hand(?) samples of the Catskill Formation collected at 1.5-m (5-ft) stratigraphic intervals and at lithologic changes along U.S. Route 220 between Picture Rocks and New Albany. These samples were analyzed for K_2O, uranium, and thorium by gamma-ray spectrometry by J. A. S. Adams. Humphreys and Friedman reported mean contents of 1.8 percent eK, 3.9 ppm eU, and 13.4 ppm eTh. Unfortunately, no lithologic or locality information was given for any of the analyzed samples, and the data are of limited value. Samples having 46, 18, 165, 16, and 31 ppm eU were reported, but locations were not provided. They may be from previously known deposits. Statements that uranium occurs at preferred stratigraphic levels were not supported.

Rose (1976) explained the essential chemical, mineralogic, and geologic features of red-bed copper deposits with regard to chloride complexing. Although his summary concerns red-bed deposits in general, most statements apply to the Picture Rocks-Sonestown area, and indeed the north-central Pennsylvania copper-uranium deposits are specifically mentioned (p. 1045–1046). Rose (p. 1036) noted that "red-bed copper deposits are introduced into their host rocks after sedimentation by flowing subsurface waters approximately in equilibrium with hematite, quartz, feldspar, and mica at temperatures less than about 75 °C...," and he concluded that chloride complexing is the probable transporting mechanism and that evaporites or escaping connate marine waters from underlying sediments may have furnished a copper-transporting fluid. Rose interpreted the apparent lack of structural control as indicating deposition of copper before structural disturbance, in this case prior to the Alleghany orogeny.

In addition to noting the earliest observations, Rose predicted the need to resolve "chalcocite,"[1] commonly used in field reports as a general term for digenite, djurleite, anilite, and other related minerals. He noted that McCauley's (1961) bornite (from Central, Columbia County) was sulfur-rich and that McCauley's photographs, representing apparent orthorhombic chalcocite, might indicate a temperature of formation of less than 103 °C, based on Roseboom's (1966) experimental study of the Cu-S system. Regarding the pH of the ore fluid, Rose noted that low-pH solutions would attack feldspar and form mica.[2]

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[1] "Chalcocite" as used in this report with quotation marks is a field term including chalcocite and/or djurleite, but generally not the distinctly bluer digenite.

[2] Moderately coarse grained muscovite is conspicuous in some of the ore horizons. Therefore this pH limit may not apply to the Picture Rocks-Sonestown area. Detailed study of possible compositional zoning and age of the so-called detrital muscovite flakes in "phyllitic" ore zones is needed despite the presence of nearby calcareous zones that might have raised the pH.

Rose (1976) noted that high-chloride waters might encounter red beds (1) near evaporites, or (2) above marine sediments that would yield connate brines during compaction. Less likely possibilities include (3) marine transgressions, and (4) arid periods. Such brines could both leach copper from normal sedimentary rocks and transport it until encountering a reducing environment associated with organic material or pyrite. Because of aqueous transport of H_2S, CH_4, and other reducing agents, such a trap might extend well beyond the original organic material. Rose also noted that brines containing copper, lead, zinc, and iron in ratios approximating their crustal abundance will precipitate "chalcocite" and pyrite, but that precipitation of lead and zinc compounds would require more strongly reducing conditions. Silver would behave more like copper. Rose noted that (1) there are thick evaporites in the Silurian rocks well beneath the uppermost Devonian Catskill Formation; and (2) considerable brine must have escaped from the marine section beneath the Catskill during diagenesis (see "Genesis" section). The moderate size of the occurrences in the Picture Rocks-Sonestown area might not, however, require generation and transport of large volumes of ore solutions.

Rose and others (1976) conducted detailed geochemical-exploration orientation surveys to determine the most efficient methods of locating the uranium prospects along the Lehigh River in Carbon County. The Beaver Lake area was studied in less detail. They concluded that (1) the acetic acid-hydrogen peroxide-leachable uranium content of stream sediments is a better guide than total uranium; (2) extractable copper in sediment deserves further testing; (3) none of the stream waters are anomalous at the detection limit of 0.2 ppb (parts per billion); (4) arsenic in sediments near ore may be anomalous compared to observed background (means of 8.75 versus 6.83 ppm arsenic, respectively), and beryllium, vanadium, chromium, cobalt, and nickel do not yield positive anomalies in sediments near ore; and (5) the extractable uranium content of stream sediments appears to be an area of interest for further prospecting (Rose and others, 1976, p. 18–19, 30, and Plate IV).

Rose and others (1976) grouped the data for anomalous, extractable uranium in sediment into a Beaver Lake Anomaly and a Muncy Creek Anomaly. Their perimeters for such anomalies seem to involve as much intuition (good though it is) as geochemical data. Hence, only the individual sites that they found to be anomalous are located on Plate 1 of the present study. Their anomaly at Dunwoody Camp, in the northwest corner of the Picture Rocks quadrangle, may be due to the extreme amounts of glacial till in that drainage. A few of their anomalies correlate well with occurrences found during the present study via historical and geologic means (Strawbridge area, Jordan Sawmill adits, and Middle Catskill Reduced Zone uranium-copper occurrence), but these occurrences were unknown to them at the time of their sampling. Hence, greater consideration should be given to those anomalies reported by Rose and others that do not have known upstream occurrences. (See also "Recommendations for Exploration and Research," p. 230.)

Price and others (1976) released raw data from a geochemical exploration orientation survey in the Williamsport area. This study included the uranium content of surface waters and groundwaters in the Sonestown quadrangle. Sample site 117, located at 41.2750°N, 76.6074°W (41°16′30″N/76°36′27″W) (3.2 km (2.0 mi) northeast of Beaver Lake; see Plate 1), yielded groundwater containing 20,200 pptr (parts per trillion) uranium, and the groundwater at site 312, located at 41.2728°N, 76.6152°W (41°16′22″N/76°36′55″W) (2.7 km (1.7 mi) northwest of Beaver Lake), yielded 35,400 pptr uranium. The sites do not appear to be related to known occurrences. Site 014, located at 41.2673°N, 76.6223°W (41°16′02″N/76°37′20″W) (draining into the northeast corner of Beaver Lake below the Jordan Sawmill adits), yielded 250 ppm uranium in suspended solids and 275 pptr in surface waters.

Lesure and others (1977) reported the results of a two-day reconnaissance of copper-uranium occurrences in north-central Pennsylvania that included the Beaver Lake district. Among their contributions are a report that mica flakes in the host rock are bent around sand grains, indicating that the mica is detrital in origin, and analyses for three rock samples from Klemic locality 8 and three from McCauley prospect 24. The more interesting data for these rock samples are summarized in Table 3. The results of their stream-sediment analyses suggest that the copper deposits should be detectable with a program that uses the copper/zinc ratios of oxalic acid extractions.

Mahar (1978) described the geology and geochemistry of the Beaver Lake district in order to evaluate uranium exploration methods and genetic models. In general, using reliable methods, he was able to make several valuable observations. Because of this and the fact that his thesis is unpublished, a summary of some of his observations is presented below and in Table 4.

(1) The occurrences are enriched in lead, silver, and mercury as well as copper and uranium (Mahar, 1978, Abstract).

(2) The measurement of the uranium content of stream-sediment samples is useful, and the otherwise low contrast is improved by using extractable uranium. Copper in sediments and uranium in stream water were not found to be useful (Abstract).

(3) A marine-transgression unit near the base of the Catskill Formation was recognized and mapped. Refinement of this reconnaissance map (Mahar, 1978, Plate 1) would permit the use of this unit as a good reference horizon. Using McCauley's (1961) reported locations, Mahar assumed that two of the copper-uranium occurrences were in the marine transgression: "However, these two sites were never found by the writer even though considerable effort was put into locating them [p. 14]." With some difficulty, these occurrences (McCauley prospects 22 and 23) were found during the present study and prove to be well above the marine-transgression unit.

(4) Mahar's Figure 7 (p. 19), a cross section of a typical lens bearing copper-uranium, illustrates the essential lithologic features such as the presence of calcareous and carbonaceous zones near the base of the lens.

(5) Mahar (p. 19-1/2 and 20) reported that he observed neither sulfide mineralization nor primary or secondary uranium minerals. Also,

Table 3. Selected Trace-Element Analyses for Rock Samples from the Beaver Lake Area

(Reported by Lesure and others, 1977, p. 614–615; quantities are in parts per million[1])

Sample no.	Site	Semiquantitative						Quantitative				Comments
		Ag	Ba	Cu	Mo	Pb	V	Hg	eU	Zn	U	
32	Klemic locality 8	3	500	200	15	700	150	<.02	80	85	74	Composite chip sample of 15 cm (6 in.) of mineralized greenish-gray sandstone from back of adit, 6 m (20 ft) from portal.[2]
33	Klemic locality 8	7	700	3,000	7	70	200	.02	30	59	—	Composite 30-cm (12-in.) sample of greenish-gray siltstone or claystone from middle of south wall of adit, 6 m (20 ft) from portal.
34	Klemic locality 8	<.5	700	50	<5	20	200	<.02	40	63	—	Composite 60-cm (24-in.) sample of grayish-red siltstone or claystone from roadcut near Klemic locality 8.
35	McCauley prospect 24	3	200	3,000	150	2,000	100	.02	<30	41	—	Composite chip sample of 30 cm (12 in.) of malachite-stained, greenish-gray sandstone containing abundant coaly remains.
36	McCauley prospect 24	<.5	1,500	50	<5	15	100	<.02	<30	42	—	Composite 60-cm (24-in.) sample of crossbedded, grayish-red sandstone above ore horizon.
37	McCauley prospect 24	7	200	3,000	10	300	150	.09	40	78	—	Composite chip sample of 60 cm (24 in.) of malachite-stained, organic-rich, greenish-gray sandstone containing scattered chalcocite grains, from north side of portal.

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[1] Data for Ag, Ba, Cu, Mo, Pb, and V were obtained via a semiquantitative emission spectrographic procedure. Data for Hg and Zn are quantitative atomic absorption results; eU is radiometric equivalent uranium, probably obtained by gamma-ray spectrometry; and U was obtained by a delayed neutron-activation procedure.

[2] "Back of adit" at 8 m (26 ft) is a stone wall to protect a private water supply. As mapped during the present study, the adit is 52.2 m (171 ft) long, and the better mineralization is behind the wall.

Table 4. *Selected Quantitative Trace-Element Analyses for Rock Samples from the Beaver Lake Area*

(From Mahar, 1978, Table 4, p. 27–30; quantities are in parts per million)

Sample no.	Ag[1]	Cu	Pb	Hg[2]	Zn	U	Comments
CLR-1 (Crystal Lake Road)	9.2	10,000	228	20	53	41.6	Fine-grained, gray sandstone near top of reduced zone about 15 ft (5 m) northwest of adit. CLR-1—5 are from McCauley prospect 24.
CLR-2	.5	35	5	19	77	3.4	Fine-grained, red sandstone directly above sandstone of CLR-1.
CLR-4	.4	83	5	24	53	3.2	Fine-grained, grayish-red sandstone, above adit and about 6 ft (2 m) stratigraphically above "ore" zone.
CLR-4	3.2	9,000	2,045	48	82	26.2	Fine-grained, gray, carbonaceous sandstone; top of ore zone, about 5 ft (1.5 m) west of adit.
CLR-4A	1.5	7,250	322	65	47	25.5	Fine-grained, gray, carbonaceous sandstone directly above CLR-4. Same general area as MHK 743 and 744 of present study and no. 25 of Lesure and others (1977, p. 614–615).
CLR-5	1.2	980	476	20	122	6.2	Silty, fine-grained, gray sandstone at base of reduced zone about 15 ft (5 m) southeast of adit.
RR-1 (Rock Run)	.4	28	11	14	77	3.3	Fine-grained, red sandstone about 25 ft (8 m) northeast of adit; probably stratigraphically below the adit floor. RR-1—10 are from McCauley prospect 28 area.
RR-5	.2	30	2	9	78	3.7	Fine-grained, grayish-red sandstone, presumably above adit.
RR-6	5.1	200	75	83	81	8.7	Gray shale and/or gray laminated mudstone about 1.5 ft (0.5 m) above adit floor. Same general area as MHK 760 of present study.
RR-8	2.7	98	1,670	65	62	56.9	Fine-grained, calcareous, gray sandstone about 3 ft (1 m) above adit floor. Same general area as MHK 759.
RR-10	2.6	217	377	111	96	39.7	Fine-grained, gray sandstone about 4.5 ft (1.4 m) above adit floor. Same general area as MHK 758.
WR-1	.3	490	11	13	85	16.2	Sketch in Mahar (1978, Appendix, p. 116) indicates sample is from a calcareous breccia containing plant fragments.[3] WR-1—6 are from McCauley prospect 28-1/2 of Mahar.

WR-2	.3	32	4	9	84	3.5	Reddish, fine-grained sandstone, about 20 ft (6 m) north of WR-1.
WR-3	.5	30	3	12	57	3.0	Reddish, fine-grained sandstone, about 30 ft (9 m) north of WR-1.
WR-4	.4	30	4	16	74	2.7	Red, 1/2-inch- (1-cm-) thick, planar-bedded, fine-grained sandstone containing grayish-red laminations, about 130 ft (40 m) north of WR-1.
WR-5	1.6	38	15	21	90	3.8	Reddish-gray, fine-grained, trough-crossbedded sandstone, about 60 ft (18 m) north of WR-1 and slightly higher stratigraphically.
WR-6	.6	336	5	7	145	2.8	Black shale with abundant malachite on bedding surface. Same general area as MHK 741 of present study.
TIV-1	2.2	60	209	24	250	2.7	Gray(?), fine-grained, calcareous, silty sandstone from a thin lens about 15 ft (5 m) east of adit. TIV-1—3 are from Tivoli adit of present report.
T1V-2	1.1	58	51	25	83	3.5	Yeilowish-gray, calcareous, marine, fine-grained sandstone at east side of entrance to adit. Same general area as MHK 789 of present study.
T1V-3	1.0	50	63	18	146	3.0	Gray, fine-grained sandstone at east side of entrance to adit and directly above T1V-2. Same general area as MHK 788 of present study.
W-1	.9	115	8	38	210	5.7	Reddish-gray, fine-grained, carbonaceous sandstone with malachite on bedding surfaces. Probably from face of old open pit below outhouse. W-1—3 are from McCauley prospect 17.
W-2	3.5	610	35	65	321	46.0	Gray, calcareous, highly weathered sandstone directly below W-1.
W-3	.9	233	5	44	270	6.6	Grayish-red, fine-grained, thin-bedded sandstone directly below W-2. MHK 731 of present study is a dump sample from the same locality.

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[1] Second decimal place has been rounded off by present authors.

[2] Results are probably in parts per billion for Hg rather than parts per million as reported.

[3] Descriptions for WR-1—6 are missing on authors' copy of Mahar's Table 4.

malachite is reported to be the only potentially economic, microscopic mineral (Abstract).

(6) Regarding the depositional environment of the mineralized lenses, Mahar (p. 20–21) observed that (a) the mineralized gray sandstone lenses are lenticular in shape[1]; (b) the lower contact is an erosional surface containing lag material and ripple marks; (c) trough crossbedding is present in the gray sandstone lenses; and (d) the reduced zones have sharp lower contacts and gradational upper contacts. This sharp lower contact "with little visible evidence for a change in permeability, suggests to this writer that the gray lenses containing the mineralization were almost certainly deposited as gray sediments" (p. 21).[2] He further reported that the channels probably trended east-west, based on the accepted transport direction of the Catskill Formation and the finding of one new lens (McCauley prospect 24-1/2 of Mahar, also called Birch Still Road reduced zone) at the same elevation as McCauley prospect 24.

Rose and others (1977, Table 10, p. 56) determined the mean composition of rock from the lower portion of the Catskill Formation in the Beaver Lake area to be as follows (values are expressed as percents): SiO_2, 76.4; Al_2O_3, 12.67; ΣFe as Fe_2O_3, 4.41; MgO, 1.37; CaO, 0.83; Na_2O, 1.10; K_2O, 1.91; TiO_2, 1.09; and MnO, 0.20. This is based on analyses of 19 samples from copper-uranium occurrences and the host rocks.

Rose and Korner (1978) reported the content of radon in groundwater near mineralization in the Lycoming-Sullivan County area to be 3 to 4,500 pCi/L (picocuries per liter) and 400 to 2,500 pCi/L in nonmineralized red beds. A threshold of 2,000 pCi/L was estimated to distinguish mineralized from nonmineralized areas. Strong anomalies of radon in groundwater are reported near Spring Run at the Lycoming-Sullivan County line and near Bethel Church (Rose and Korner, 1978, Figure 7). Uranium in groundwater is also reported to indicate mineralization.

Rose and Korner (1978) reported that the range of values of radon in stream waters (as contrasted to groundwaters) near known uranium occurrences in the Beaver Lake area is 1 to 100 pCi/L. Because these values are low compared to background samples from other areas, perhaps because of degassing effects and groundwater influx, they concluded that the method is not useful, despite a possible anomaly of 188 pCi/L radon and 0.26 mg/L (milligrams per liter) uranium in a sample from the west branch headwaters of Beaver Run. This sample appears to be down the hydraulic gradient from the Copper Hollow (p. 96) group of prospects. In addition to data pertaining to the project area, Rose and Korner presented a lucid discussion of radon in groundwater and the factors unrelated to mineralization that control its concentration.

Applin and Langmuir (1978) studied the geochemistry of 41 groundwater samples in the Picture Rocks-Sonestown uraniferous areas with respect to possible exploration techniques. As with some other geochemical studies of the Picture Rocks-Sonestown area, their interpretations were hampered by inadequate knowledge of the geology, distribution, and composition of the deposits themselves. Their Figure 15 suggests that sampling was concentrated near known occurrences. Because of this and the reasons listed below, statements such as, "These anomalies target most of the known uranium occurrences..." (p. 69) and, "In most cases, anomalous uranium is observed at distances of up to one or two kilometers [0.6 or 1.2 mi] from known uranium occurrences" (p. 61) are of dubious value. The number and small size of the known occurrences and abundance of calcareous breccia do not seem to have been adequately considered. Groundwater sampling is stated to be of value despite the scarcity of wells in the general area and especially in the upper Catskill Formation.

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[1] This lenticular shape may not apply to some of the occurrences found higher in the Catskill Formation during the present study.

[2] The present authors suspect a greater permeability in the base of the channels than in the underlying shale.

In contrast, the analytical, statistical, and geochemical studies of Applin and Langmuir (1978) are helpful. They found the dissolved uranium content of groundwater to range from 0.1 to 7.8 ppb with a mean of 1.5 ppb. Compared with the Carbon County uraniferous areas, the Picture Rocks-Sonestown groundwaters are richer in calcium and bicarbonate and total dissolved solids. A summary of their results for the two areas is presented in Table 5.

Their study indicates that the Picture Rocks-Sonestown groundwater has higher specific conductivity, pH, calcium, VO_2^{2+}, HCO_3^-, PO_4^{3-}, and SO_4^{2-} contents and lower copper, lead, and radon contents than does Carbon County groundwater. In separate calculations they indicated the importance of carbonate complexing for uranium in groundwater.

Figure 15 and Table 17 of Applin and Langmuir (1978) show that 12 groundwater samples in the project area contain more than 0.2 ppm copper. A correlation with known deposits is reported (p. 69), but is not convincing.

LKB Resources, Inc. (1978) reported the results of an airborne gamma-ray spectrometer survey flown at 400 feet (122 m) with a total Earth-aimed sensor volume of 2,154 in.^{3} (35.3 L). The Picture Rocks-Sonestown area was traversed by five north-south flight lines (nos. 108–112) and one east-west line (no. 208). A total of seven eU anomalies (nos. 116–122) were reported for the southern edge of the area, mostly along flight line 208. Because of the disproportionate number of anomalies along flight line 208 in the Williamsport 1° by 2° area (implying instrumental drift) and the unfavorable stratigraphy, they were not investigated. Nevertheless, LKB reported that nos. 120 and 122 are preferred anomalies because of significant enrichment of eU over eTh and eK.

Contemporaneous Studies (1979–80)

Unlike most reports discussed in the "Previous Studies" section, the reports noted below were generally not available during the early, formative stage of the present study. Also, they tend to deal with geochemical exploration rather than geology and mineralogy. The profusion of such studies appears to have resulted from the documentation by McCauley (1961) and Klemic (1962) of a moderate number of copper-uranium occurrences in an

Table 5. *Comparison of Groundwater Chemistry of the Picture Rocks-Sonestown versus Carbon County Uraniferous Areas*

(From Applin and Langmuir, 1978, Tables 8 and 9, p. 45–46)

Variable	Mean Picture Rocks-Sonestown	Mean Carbon County
Specific conductance (micromhos)	253	54
pH	6.86	5.41
Eh (V)	.442	.480
Ca (ppm)	22	3.7
Mg (ppm)	2.4	1.5
Na (ppm)	10	8.3
K (ppm)	1.2	.6
Cd (ppb)	1.8	.9
Co (ppb)	1.1	2.1
Cr (ppb)	1.1	.8
Cu (ppb)	140	260
Fe (ppb)	23	36
Mn (ppb)	28	47
Ni (ppb)	2.6	4.0
Pb (ppb)	1.9	5.1
UO_2^{2+} (ppb)	1.46	.05
Zn (ppb)	33	33
Cl (ppb)	21	20
HCO_3^{1-}	63	12
PO_4^{3-}	25	6.6
SO_4^{2-}	13	2.2
VO_4	5.8	5.1
Rn (pCi/L)	1,590	2,650

unpolluted environment. These factors, combined with the onset of the National Uranium Resource Evaluation (NURE) program and proximity to The Pennsylvania State University, at this time in the forefront of geochemical-exploration theory and technology, led to the Beaver Lake district becoming a veritable test pad for ‘‘black boxes.’’

Heffner (1979) reported geochemical-exploration data for the Williamsport 1° by 2° area. His strongest uranium anomalies for the Picture Rocks-Sonestown area are summarized in Table 6 on the following page.

Pirc (1979) examined the uranium, thorium, Fe^{2+}/Fe^{3+}, and other parameters of 272 samples of the Catskill Formation of eastern Pennsylvania. His study focused on the Carbon County area, but his conclusions regarding iron may apply to the Picture Rocks-Sonestown area. He (p. 138–139) made the following conclusions:

(1) Fe, Fe^{2+}, and Fe^{3+} decrease with increasing grain size in both red and gray rocks.

(2) Fe^{2+}/Fe^{3+} increases with increasing grain size in red, but not gray, rocks.

Table 6. *Uranium Anomalies Observed in the Picture Rocks-Sonestown Area by Heffner (1979)*

		Well depth	
Location	U in groundwater (ppb)	(m)	(ft)
41.2508°N, 76.5702°W (41°15'02"N, 76°34'12"W)	1.549	57	190
41.2992°N, 76.6135°W (41°17'57"N, 76°36'48"W)	3.440	52	170
41.3309°N, 76.6676°W (41°19'51"N, 76°40'03"W)	2.723	64	210
	U in stream sediments (ppm)		
41.3145°N, 76.6691°W (41°18'52"N, 76°40'08"W)	21.9		

(3) Fe in shales and fine-grained sandstones tends to be higher in red than in gray rocks.

(4) Fe^{3+} tends to be higher in red than in gray rocks and Fe^{2+} higher in gray than in red rocks. Therefore, Fe^{2+}/Fe^{3+} is lower in red than in gray rocks.

(5) Chlorite is the predominant iron-bearing species in both red and gray rocks. Both chlorite and illite are enriched in gray rocks. Hematite contains some of the iron in red rocks.

Rose and others (1980, p. 125) noted that the enrichment of iron and depletion of uranium in fine-grained red, relative to gray, sediments is believed to originate during early diagenesis by mobility of uranium under oxidizing conditions and iron under reducing conditions. They speculated that uranium leached from fine-grained red sediments furnishes a source for enrichment of uranium in gray sandstones and shales.

During the period 1978–80, A. T. Smith, a master's degree candidate at The Pennsylvania State University, studied 40 copper-uranium occurrences in the Catskill Formation of Pennsylvania. He and his advisor, A. W. Rose, generously shared their hypotheses for the 43rd Field Conference of Pennsylvania Geologists (Sevon and others, 1978). The authors of the present report in turn provided A. T. Smith with the locations for the Jordan North Mountain uranium prospects 1 and 2, Jordan Sawmill adits, Sonestown Nose uranium trench of Gill-Jordan, Bench Mark 359 uranium-copper-lead occurrence, and Middle Catskill Reduced Zone uranium-copper occurrence, as well as the Rock Run uranium occurrence and McCauley prospect 22 sites described in the Guidebook of·the 43rd Field Conference, to increase the stratigraphic range studied by A. T. Smith. A. T. Smith and Rose (1980) presented their preliminary observations in an abstract and A. T. Smith (1980) presented the details.

A. T. Smith (1980) examined 10 occurrences in the Picture Rocks-Sonestown area during his study. Of the 23 mineralized samples collected from this area, 14 were sandstones, 6 siltstones, and 3 calcareous lag deposits. Quantitative analyses for copper and uranium in these 23 samples and in 50 other samples from outside the Picture Rocks-Sonestown area are presented in Table 7 (Appendix II of A. T. Smith, 1980). The initial samples seem to have been 1/2- to 2-kg (1- to 4-lb) "grab" samples.

Based on detailed observation of sedimentologic features, A. T. Smith (1980) sketched the stratigraphic features at each site and summarized the depositional environments as 57.5 percent tidal, 25 percent coastal plain, and 17.5 percent small, meandering-stream environments (p. 61). He also reported tidal features within 20 m (66 ft) stratigraphically of 95 percent of the deposits. He noted that, from bottom to top, approximately 13 percent of the occurrences are in the Irish Valley Member, 49 percent in the lower third of the Sherman Creek Member, and 6 percent in the Duncannon Member of the Catskill Formation (p. iii).

A. T. Smith (1980, p. 40 and 53) divided the deposits into two types. Type I consists of copper and uranium mineralization localized in reduced siltstones that are rich in fossil plants. These siltstones are associated with reduced, fine- to medium-grained sandstones, the greatest copper and uranium occurring in the siltstone near the contact with the sandstone. He included the Jordan North Mountain, Jordan Sawmill adits, and possibly the U.S. Route 220 occurrences in this type (p. 41). Type II consists of copper and uranium mineralization localized in reduced calcareous lag deposits. McCauley prospect 24, McCauley prospect 28, McCauley prospect 28-1/2 of Mahar, Jordan borrow pit, Tivoli adit, Klemic locality 12, and Sonestown Nose uranium trench of Gill-Jordan (mistakenly identified as Klemic locality 13) are included in this type (p. 41). Both Types I and II are noted at McCauley prospect 22.

Although discussed further elsewhere (see sections on "Essential Features of a Typical Lens" and "Genesis"), it should be noted here that (1) this classification scheme may be less suitable for the occurrences found and described in the area of the present study than for the larger area studied by A. T. Smith; and (2) the bias of the present authors is toward somewhat higher energy depositional environments, i.e., toward the relatively few sandstone host occurrences located somewhat higher in the Catskill Formation. This may be due in no small part to the higher amounts of energy spent by the authors in channel sampling mineralized sandstone samples in the Picture Rocks-Sonestown area. As the present authors observed substantial mineralization in sandstone at the same localities where A. T. Smith described it in siltstone, there may also be a difference in the use of these rock terms. As a field term used in the present study, sandstones are composed of grains coarser than about 0.05 to 0.1 mm. This is much larger than the grain size of siltstones, only the coarsest of which are composed of grains visible to the unaided eye.

Contact with property owners during the early stages of field work by the authors of the present report revealed that at least two major companies were exploring for uranium within the project area. Leases for both were reported to have been terminated after drilling. The positions of the holes located for the authors by the enthusiastic residents are shown on Plate 1. Based on information volunteered by these residents, it is estimated that 30

Table 7. *Uranium and Copper Analyses of Rocks in the Picture Rocks-Sonestown Area*

(From A. T. Smith, 1980, Appendix 11, p. 209-210)

A. T. Smith's sample no.	Location[1]	Cu (%)[2]	U (ppm)	Lithology	Color[3]
6116	New U.S. Route 220 uranium-copper occurrences	.72	302.9	Fine-grained sandstone	5G6/1
6120	do.	.55	786.2	do.	N5
6121	Klemic locality 12	.11	8.2	Medium-grained calcareous sandstone	5B7/1
6127	do.	1.13	45.8	Calcareous lag	N6
6128	do.	.15	10.5	do.	N5
6129	Jordan borrow pit	.15	10.6	do.	N6
6131	do.	.40	41.0	Calcareous sandstone	N6
6135	McCauley prospect 22	2.21	1,615.4	Siltstone	N7
6136	do.	2.48	820.6	"Calcareous" siltstone	N4
6137	do.	.93	560.9	do.	N5
6140	McCauley prospect 28	.05	51.9	Medium-grained sandstone	N6
6146	do.	.06	1,882.0	Fine-grained sandstone	N6
6147	do.	.09	5.5	Medium-grained sandstone	N6
6149	McCauley prospect 28-1/2 of Mahar	.33	15.2	Calcareous sandstone	N5
6150	McCauley prospect 24	.37	13.2	Siltstone	5G4/1
6151	do.	1.09	141.9	Calcareous sandstone	N5
6154	do.	.07	28.1	Fine-grained sandstone	5Y7/2
6156	Tivoli adit	.07	10.1	Calcareous siltstone	N4
6161	Jordan Sawmill adits	.58	14.1	Siltstone	N4

Table 7. *(Continued)*

A. T. Smith's sample no.	Location[1]	Cu (%)[2]	U (ppm)	Lithology	Color[3]
6163	Jordan North Mountain uranium prospect	.12	128.6	Medium-grained sandstone	5G4/1
6165	do.	.02	2.8	do.	5YR5/2
6167	do.	.47	3.5	do.	5R2/6
6170	"Klemic locality 13" (actually Sonestown Nose uranium trench of Gill-Jordan)	.05	101.8	Fine-grained sandstone	N5

[1] Locality nomenclature has been adjusted to coincide with that of present study.

[2] Although direct comparison is difficult, these copper analyses are consistently high by on the order of 50 percent. Intuitively, this suggests to the present authors that A. T. Smith's sampling was somewhat more biased toward the high-grade portions of mineralization, whereas the present authors attempted to channel sample the entire "mineralized" horizon based on the limits of radioactivity defined with a Geiger counter probe and copper minerals observed with a hand lens. Compared to one another, the uranium values are erratic, suggesting perhaps that uranium is more erratically distributed in each occurrence than is copper.

[3] From *Rock-color chart* of Goddard and others (1975).

to 50 holes having an average depth of 150 m (500 ft) were drilled in 1978.[1] Many of the observed holes were capped with the driller's name, Wieand Brothers, Milton, Pennsylvania, and, at the owner's request, were left in a condition so as to be usable for emergency water supplies. The owners of these drilled tracts appear to have been pleased with their experience with the exploration industry.

This commercial drilling was apparently done with rotary equipment. Of the chip piles not removed by residents for road gravel, only one showed signs of mineralization. This is at the dry drill hole E (nomenclature arbitrarily assigned by the authors) on the Marquardt tract (41°21′14″N/76°36′22″W). Unlike most of the chip piles, which yielded radiometric field assays of 10 to 15 ppm eU (the actual U_3O_8 was typically found to be roughly half the eU for the project area), the chip pile at drill hole E yielded 20 ppm eU (approximately 10 ppm U_3O_8?) and contained about 10 percent reduced, micaceous, fine- to medium-grained sandstone. Some of these chips had an "arkosic"-looking alteration, and one chip included a carbonaceous plant fragment. The remainder of the chips were typical oxidized, grayish-red, micaceous siltstone and fine-grained sandstone.

Cook (1981) reported stream sediment analyses for the Williamsport 1° by 2° NTMS area, which include data for the Picture Rocks and Sonestown quadrangles. Analyses are presented for silver, copper, molybdenum, lead, tin, zinc, extractable uranium, and several other elements. Cook's most interesting sample, PALY 042 from Roaring Run near the confluence with Muncy Creek (41.2896°, or 41°17′22″N; 76.7103°, or 76°42′37″W), is reported to contain 100 ppm tin. Several other tin and lead anomalies are reported for the Williamsport 1° by 2° area, as well as separate, individual strong anomalies for molybdenum, nickel, and zinc.

GENERALIZED DESCRIPTION OF DEPOSITS

Clustering

As noted by McCauley (1961, p. 23), copper-uranium occurrences in the Catskill Formation tend to be clustered on a regional basis. McCauley recognized three clusters in north-central Pennsylvania: the Beaver Lake district (approximately equivalent to the Picture Rocks-Sonestown area of the present study); the New Albany district, Bradford County; and the Central district, Columbia County. Although part of the apparent clustering is due to intervening belts of Devonian marine and Mississippian rocks, the present study weakly supports the concept of regional clusters. This is based on the apparent absence of copper-uranium mineralization in the western third of the Picture Rocks quadrangle and southeastern portion of the Sonestown quadrangle. This apparent absence is partially supported by the car-borne scintillometer survey[1] (despite a greater proportion of shale and associated ^{40}K in the southern portion of the region), conversation with local prospectors, and brief examination of several reduced zones exposed in roadcuts. A weak, unchecked gamma-ray anomaly on the south side of Pa. Route 118 about 0.23 km (0.14 mi) to the east of the Sonestown quadrangle should be checked to see if a "bridge" of occurrences can be found between the Beaver Lake and Central districts.

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[1] This estimate yields an approximate total of 6 km (4 mi) of drilling. Reports of drilling to the east of the Sonestown quadrangle were not checked or included.

In addition to regional clusters, occurrences also appear to be clustered on a local scale within the project area. As noted in the "Genesis" section of this report, the 55 described occurrences have been grouped into 12 clusters of limited geographic and stratigraphic extent and one miscellaneous category (see table of contents). One of the better known examples of such local clustering occurs at the Sonestown Nose (Plate 1, northeast portion of Sonestown quadrangle). In this area, there appear to be three favorable stratigraphic horizons, each containing several small copper-uranium-bearing lenses, stacked stratigraphically one on top of the other. Although one tends to "look for peanuts in a peanut patch," the presence elsewhere in the district of extensive, barren reduced zones containing carbonaceous material suggests that certain horizons and areas were indeed more favorable to mineralization. The inability of the authors and earlier prospectors to find copper-uranium in the reduced zones in the western portion of the Picture Rocks quadrangle weakly supports the legitimacy of the concept of local clusters.

Essential Features of a Typical Lens

Essentially all of the copper-uranium mineralization found occurs in gray, reduced[2] clastic lenses and beds within an otherwise reddish-gray clastic sequence. Rare exceptions include apparent trace uranium in transitional and oxidized rocks overlying a reduced host, such as at Strawbridge Northwest uranium-copper lens. Only limited portions of the reduced beds in the project area are mineralized.

Typical grain sizes for the reduced host rock range from coarse silt-very fine sand (1/16 mm) to medium to coarse sand (1/2 mm), and include "calcareous breccias" that contain shale chips and other fragments up to the centimeter range. Most of the occurrences described in earlier studies are in the lower Catskill and have coarse silt to very fine sand hosts. The present study includes occurrences in the upper Catskill that are in fine- to medium-grained sandstones, generally occurring at elevations above 1,200 feet (approximately 365 m).

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[1] Except for the lower portion of the Trimmers Rock Formation, the scintillometer survey covered all roads and trails accessible to a four-wheel-drive jeep within the two quadrangles. A Mt. Sopris SC–132 scintillometer and R–132A chart recorder were used at vehicle speeds of 16 or 32 km/hr (10 or 20 mi/hr). In most cases, the traverses extended slightly beyond the quadrangle boundaries to convenient reference and turning points.

[2] Most reduced lenses are enriched in Fe^{2+} relative to Fe^{3+} and most contain gray and greenish minerals such as chlorite rather than the reddish mineral hematite.

The observed copper-uranium occurrences are stratiform and their shapes typically range from lenticular for the smaller occurrences to tabular for the larger. Most of the small lenses, such as at McCauley prospect 24, occupy paleostream channel cuts having less than 1 m (3 ft) of original erosional relief. Figure 7, adapted from Mahar (1978, Figure 4, p. 19), is an idealized cross section through such a lenticular deposit. From the bottom up, a typical lens consists of (1) an erosional cut into grayish-red (10R4/2 or 5R4/2) mudstone, in sharp contact with overlying (2) medium-gray (N5) calcareous breccia containing centimeter-sized gray and red shale chips, phosphatic freshwater fish remains, and carbonaceous fossil plant fragments in a partly crystalline limestone matrix with some crudely spherical calcareous nodules; (3) medium-gray (N5), medium-grained sandstone that is crossbedded, contains carbonaceous plant fragments, and is calcareous near the base; in most occurrences, this medium-grained sandstone grades upward into medium-gray (N5), fine-grained sandstone which has lower amplitude crossbeds and overlying, more planar beds containing abundant millimeter-sized muscovite flakes on bedding partings; (4) a transition zone of grayish-brown, very fine grained sandstone is a nonessential feature of this model present at some occurrences; and (5) grayish-red (5R4/2), very fine grained sandstone to siltstone that is commonly more crossbedded near the base and has thinner, planar beds near the top.

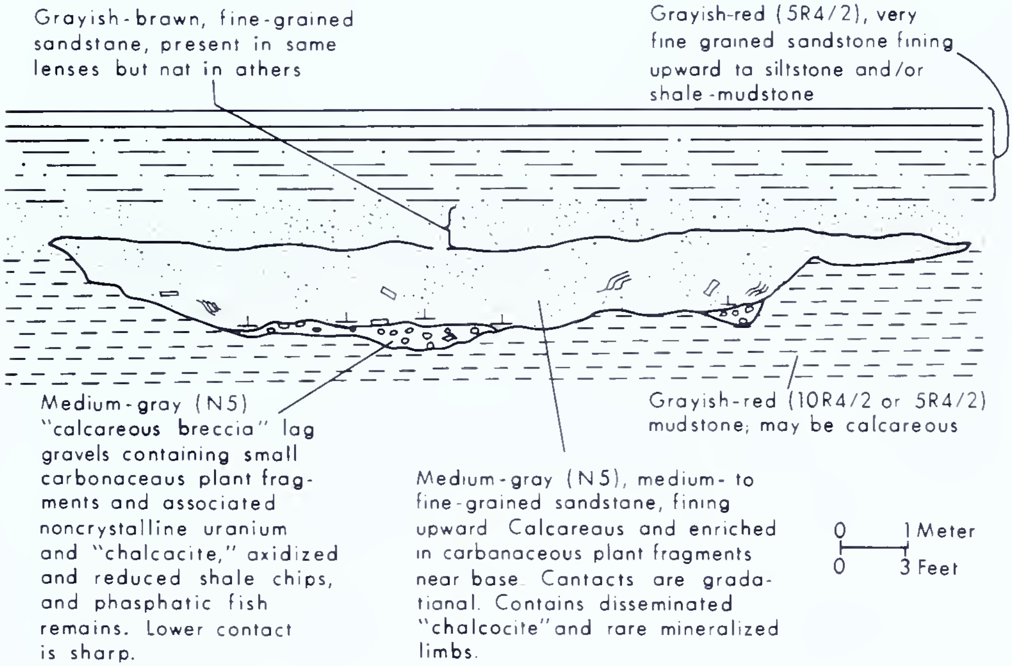
Grayish-brown, fine-grained sandstone, present in some lenses but not in others
Grayish-red (5R4/2), very fine grained sandstone fining upward to siltstone and/or shale-mudstone
Medium-gray (N5) "calcareous breccia" lag gravels containing small carbonaceous plant fragments and associated noncrystalline uranium and "chalcocite," oxidized and reduced shale chips, and phosphatic fish remains. Lower contact is sharp.
Grayish-red (10R4/2 or 5R4/2) mudstone; may be calcareous
Medium-gray (N5), medium- to fine-grained sandstone, fining upward. Calcareous and enriched in carbonaceous plant fragments near base. Contacts are gradational. Contains disseminated "chalcocite" and rare mineralized limbs.
0 1 Meter
0 3 Feet

Figure 7. Idealized cross section through a lenticular copper-uranium deposit (modified from Mahar, 1978, Figure 4, p. 19). The calcareous breccia contains both copper and uranium, chiefly with small carbonaceous plant fragments. The gray sandstone contains similar mineralized fragments and finely disseminated "chalcocite."

It should be noted that the contact of the reduced calcareous breccia at the base of a lens with the underlying oxidized mudstone is typically extremely sharp with respect to lithology, grain size, and color. The upper contact of a lens is typically not as sharp, and in some cases is transitional. Carbonaceous plant material ranges from macerated fragments less than 1 mm across to logs up to 6 cm (2 in.) across and 1.2 m (4 ft) long. Most plant fragments in the calcareous breccia are less than 5 mm (0.2 in.) across, whereas those in the sandstones commonly range from 1 to 5 cm (0.4 to 2 in.).

The larger tabular occurrences, such as the Sonestown Nose uranium trench of Gill-Jordan, differ only in that (1) the length/thickness ratio and size are greater; (2) the calcareous breccias are not consistently at the base, but appear to be more randomly distributed; (3) the overall sedimentology is more complex and includes planar beds as well as crossbedded units; and (4) the distribution of mineralization is less predictable. The lenticular deposits probably represent a simple channel that was preserved without being reworked, whereas the tabular deposits were reworked as a stream channel meandered across an established floodplain of low relief.

The observed mineralized occurrences range from a few centimeters to a few meters in thickness, and from a meter (3 ft) to nearly 100 meters (300 ft) in strike length. True dimensions are difficult to estimate because of the general lack of data in the third dimension and the difficulty of determining the relationship between an exposed face and a meandering-stream channel.

Distribution of both copper and uranium is not uniform, but they do tend to be stratabound and enriched in (1) basal and interbedded (with sandstone), reduced calcareous breccia lenses; (2) basal and interbedded (with siltstone and/or calcareous breccia) reduced sandstones; and (3) to a lesser extent, planar-bedded transitional sandstones near the top margins of a lens (such as at McCauley prospect 19). Uranium tends to be associated with carbonaceous plant fragments, whereas copper also is present as fine-grained disseminations. The copper occurs as "chalcocite" in sandstones and, to a lesser extent, in calcareous breccia.

Although vertical-variation sampling problems were overcome by taking true channel samples, the lesser problem of lateral variation was not (see also the discussion of sampling in "Format of Descriptions of Occurrences"). For example, channel samples MHK 734 and 735, cut less than 1 m (3 ft) apart in the same horizon, yielded analyses of 260 and 130 ppm U_3O_8, 13,500 and 12,500 ppm copper, 680 and 460 ppm arsenic; and 1,000 and 900 ppm lead, respectively.

Keeping the measurement, homogeneity, and sampling problems in mind, the approximate amounts of metals in a typical "good size" lens are estimated as follows:

(1) The basal calcareous breccia[1] is assumed to be 0.5 m (1.6 ft) thick and 5 m (16 ft) long, and to continue into the outcrop for 5 m (16 ft) with a grade of 34 ppm U_3O_8, 4,150 ppm copper, and 6 ppm silver.

(2) The overlying gray sandstone[2] is assumed to be 1.0 m (3.3 ft) thick and 10 m (33 ft) long, and to continue into the outcrop for 10 m (33

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[1], [2] See footnotes 1 and 2 on following page.

ft) with a grade of 53 ppm U_3O_8, 2,250 ppm copper, and 7 ppm silver.

These assumptions and an approximate density of 2,400 kg/m³ (150 lb/ft³) yield the following:

	"Ore" m³ (ft³)	"Ore" kg (lb)	U_3O_8 kg (lb)	Cu kg (lb)	Ag kg (troy oz)
Calcareous breccia[1]	12.5 (440)	30,000 (66,000)	1.02 (2.25)	125 (275)	0.18 (5.8)
Gray sandstone[2]	100 (3,500)	240,000 (529,000)	12.72 (28.04)	540 (1,190)	1.68 (54.0)
Totals	112 (3,940)	270,000 (595,000)	13.74 (30.29)	665 (1,465)	1.86 (59.8)
Approx. value/kg Oct. 1981			$51.80 ($23.50/lb)	$1.79 ($0.81/lb)	$275 ($8.55/troy oz)
Approx. value/occurrence			$712	$1,190	$511

Obviously, such lenses lack the grade, thickness, and lateral continuity to be classified as "ore." Recovery problems caused by mineralogic complexity further reduce the economic potential. For example, much uranium and copper are present as both primary and secondary complex minerals. Thus, of the potentially recoverable $2,413 of Cu-$U_3O_8$-Ag, probably only half could be recovered by any simple process. Such poor recovery might reduce the value of the ore from $8.94/metric ton ($8.11/short ton) to approximately the value of any sound rock used for aggregate. Clearly, this type of deposit could not be exploited under any foreseeable economic conditions.

Primary Minerals[3]

The calcareous breccia in a typical lens contains probable primary uranium oxide in an apparently noncrystalline form associated with carbonaceous material. Primary copper occurs associated with the uranium as "chalcocite"[4] replacements of carbonaceous plant fragments and, more importantly, as fine-grained disseminations. From examination of several polished sections by reflected-light microscopy and from X-ray powder diffraction, it is known that the chalcocite grains are anhedral, composite grains from 0.1 to 1 mm in diameter. The chalcocite commonly contains bornite cores which have very thin intermediate rims of digenite. Most polished sections contain several polymineralic composites that have sparse, tiny galena blebs in the chalcocite and partial outer rims of tennantite (Figure 8).

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[1] Based on the median composition for calcareous breccia channel samples PRS-1 and 5 plus MHK 729, 736, 742, 743, 747, 754, 756, 759, 761, 763, 764, 766, 769, 775, and 777.

[2] Based on the median composition for sandstone channel samples PRS-2, 3, 7, and 8 plus MHK 727, 728, 730, 731, 732, 733, 734, 735, 737, 739, 740, 744, 745, 746, 748, 749, 750, 752, 753, 755, 757, 758, 762, 767, 768, 770, 771, 772, 773, 774, 776, 778, 780, 781, 782, 784, 787, 790, 791, 793, and 794.

[3] As used herein, primary minerals are those formed during the initial concentration of metals into the occurrence, i.e., probably during diagenesis.

[4] As used herein, "chalcocite" is a descriptive field term for all combinations of copper sulfides such as chalcocite and djurleite that appear gray to the unaided eye. The distinctly bluer mineral digenite is excluded.

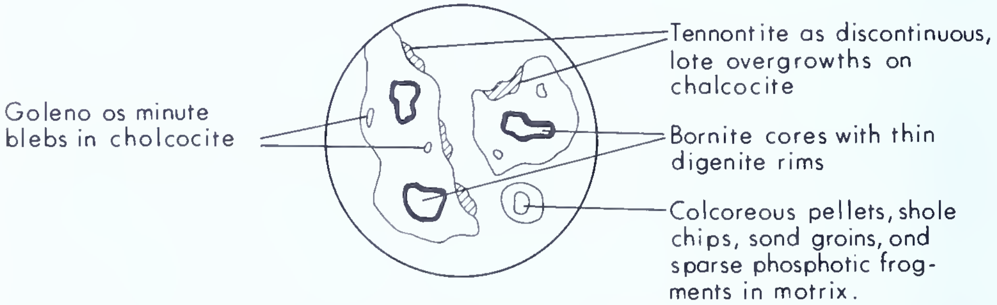
Galena as minute blebs in chalcocite
Tennantite as discontinuous, late overgrowths on chalcocite
Bornite cores with thin digenite rims
Calcareous pellets, shale chips, sand grains, and sparse phosphatic fragments in matrix.

Figure 8. Schematic sketch of "chalcocite" blebs in a polished section of calcareous breccia. The field of view is approximately 2 mm. Idaite occurs in place of some of the bornite in sandstone host specimens.

"Chalcocite" replacements of large sections of fossil tree limbs typically consist of chalcocite with numerous digenite-rimmed bornite cores, but with substantial to nearly complete replacement to supergene(?) covellite. As recovered, most "chalcocite" limb sections contain secondary copper minerals along fractures.

In addition to having textures and mineral relationships similar to those described for calcareous breccias, disseminated copper sulfides in sandstones tend to be mineralogically more complex and variable. The bornite in sandstones has two additional textures: (1) some bornite contains very thin to thick exsolution lamellae of chalcopyrite; and (2) some is orange, anisotropic bornite-idaite that may also contain chalcopyrite exsolution lamellae. Exceptions include the sulfide grains in sample MHK 778 (R. Quava property), which consist entirely of chalcopyrite but have highly serrated, gangue-filled margins, and, at the other extreme, the sulfide grains in sample MHK 787 (Old Farm uranium-copper occurrence), which consist entirely of anhedral chalcocite.

Sulfide replacements of the larger sections of fossil tree limbs typically consist of major amounts of digenite and covellite, the latter especially enriched near fractures. Relict traces of bornite, discontinuous chalcocite patches, and trace tennantite also occur in some sections. Except in a very few limb sections, the amount of remaining unreplaced and unaltered carbonaceous material is large compared to the amount originally present. This is especially true for the fine-grained, disseminated carbonaceous material.

Uraninite has been identified from only two locations (Copper Hollow 8 prospect and the 80-m site at the Sonestown Nose uranium trench of Gill-Jordan). The samples are not ideally suited for isotopic age determinations, and it cannot be determined if the uraninite is truly primary.

Secondary Minerals[1]

In a typical lens, the copper sulfides appear to alter to brochantite in protected fractures in noncalcareous sandstones, and then later to malachite or, less commonly, chrysocolla. In a calcareous host, major malachite and minor azurite form directly.

Galena in sandstone tends to alter to anglesite, whereas that in calcareous hosts alters to cerussite. A "linarite-like," so-far-unidentified mineral has been found in weathered zones rich in both lead and copper. Kasolite occurs in zones rich in both lead and uranium.

The common uranium secondary minerals include both silicates and phosphate-arsenate partial solid solutions. Examples in the former category are uranophane and kasolite and, in the latter, metatorbernite and metazeunerite. Based on the relative abundance of secondary uranyl silicates in this area, in Carbon County (including vanadiferous deposits), and in the Reading Prong, it does not appear that silica should be excluded from solution-mineral equilibria, as was done by Applin and Langmuir (1978, p. 133).

The absence of the species autunite and meta-autunite from the project area remains problematic, although mineral equilibrium models have not been attempted. The appropriate cations should be available somewhere in the weathered calcareous breccia environment to form $Ca(UO_2)_2(PO_4)_2 \cdot 2\text{–}12H_2O$. The presence of the copper-bearing members of the same mineral group in sandstone host deposits, the apparent solubility of calcite from calcareous rocks based on preferential weathering, and the relative abundance of phosphorus from weathered fish fossils,[2] suggests that perhaps carbonate complexing is permitting uranyl (UO_2^{2+}) ions to escape. This is also suggested by the relative abundance of meta-autunite and other members of the autunite group in the Carbon County uranium occurrences. The Carbon County deposits also occur in Catskill Formation sandstone, but calcite and calcareous breccia are lacking in that area. Biologic activity from lime-loving mosses and lichens via organic complexing, pH change, exchange reactions, or simply longer water retention, also needs to be considered for the Picture Rocks-Sonestown area.

For whatever reason, the near absence of secondary uranium minerals in calcareous breccia suggests that the reported assay values for the sampled calcareous rocks might be in error on the low side. It also suggests the need for caution in designing geochemical prospecting procedures so that mobile uranium from the small calcareous breccia occurrences does not become the focus of exploration.

A number of sandstone samples that are moderately enriched in copper and uranium relative to normal mineralized gray sandstones have a peculiar mottled "maroon" color which, although it cannot be accurately described on a rock-color chart, is in some places nearest to dusky red (5R3/4).[3] The color occurs within otherwise gray, reduced zones and may be most intensely developed in weathered exposures. It also occurs at other localities as centimeter-thick halos around carbonaceous plant fragments in reduced sandstone (10-m site at Sonestown Nose Reduced Cap copper-uranium zone; McCauley prospect 29; and Klemic locality 12, northeast site). This latter phenomenon suggests that the coloration is not caused by early hematite.

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[1] As used herein, secondary minerals include those formed in the recent weathering environment. Included as secondary are the various copper and uranium "blooms" and "ochres" of the prospectors. "Supergene," as used by some, would apply, although, with the possible exception of covellite, no recent concentrations are apparent.

[2] A composite of the 17 calcareous breccia samples listed in Table 9 contains 0.18 percent P_2O_5.

[3] The color is variable within and between occurrences. Also, field conditions precluded precise color descriptions.

J. H. Barnes (personal communication, October 26, 1981) reported that samples with this penetrative mottling (MHK 767, 773, and 776) yield a few X-ray diffraction spacings that correspond to hematite. As hematite has been demonstrated previously to be the pigment in normal oxidized Catskill sediments (Pirc, 1979, and others) this is not too surprising in itself. What is difficult to understand is why this localized mottling and oxidation has occurred. Although radiation halos in feldspar, serpentine, and quartz are common in the Reading Prong of Pennsylvania, those radiation sources are older and more intense. A more plausible alternative to oxidation induced by ionizing radiation is oxidation of an unstable mineral in the recent weathering environment. This would also be consistent with the mottled appearance of many samples. Some of the weak diffraction spacings at 2.71 and 1.889 Å could be caused by pyrite or marcasite. If these represent unaltered iron sulfide, it may mean that the higher grade sandstone occurrences contain more pyrite than is readily apparent. A. W. Rose (personal communication, 1982) also noted that both empirical and experimental evidence suggests that the formation of hematite (rather than goethite) is promoted by the presence of copper. This is consistent with the higher median content of copper in "maroon" sandstone than in all sampled mineralized sandstones.

GENESIS

Although the genesis of red-bed copper-uranium occurrences in the project area cannot be definitively determined from a descriptive study such as the present one, the presence of some features and absence of others limits the types of processes that can be invoked. Observations and interpretations believed to be relevant include the following:

(1) Phosphatic fish fragments in the calcareous breccias are not enriched in uranium as they might be if the fish lived in waters that were anomalously enriched in uranium. This would have occurred by substitution of UO_2^{2+} for Ca^{2+} into the growing apatite structure. Therefore, uranium mineralization is tentatively placed after sedimentary deposition.

(2) "Chalcocite" preferentially replaced fusain rather than vitrain in the larger carbonaceous plant fragments. Because the distribution of vitrain versus fusain does not appear to reflect original wood textures in the carbonaceous limbs observed in the study area, copper mineralization is placed after the onset of coalification. According to Teichmüller and Teichmüller (1966), coalification is primarily a function of the length of time the plant debris is held at an elevated

temperature. Assuming that the source of heat was simple burial in a region of normal geothermal gradient (approximately 30 °C/1,000 m), a temperature of only about 65 °C would have been reached at the base of the Catskill Formation by the end of Mississippian deposition.[1] Based on experiments and measurements by Teichmüller and Teichmüller, a steady increase over 30 m.y. (million years) to such a temperature might barely be adequate to permit preferential replacement of fusain. Although one cannot accurately estimate the necessary conditions for differential coalification, these crude assumptions do suggest the probable lapse of millions rather than thousands of years between deposition and copper mineralization.

(3) A pyrite nodule from the Sheets "coal mine" exhibits postdepositional bending of surrounding sediments. This apparent soft-sediment deformation limits growth of the pyrite and, presumably, iron reduction to early diagenesis. Uranium reduction may be synchronous with that of iron.

(4) At least some of the lead mineralization (e.g., galena along cleat (joints) at the Sheets "coal mine" and McCauley prospect 19) postdates the development of cleat in the coal. Based on the late position of galena relative to copper sulfides in the paragenesis and Nickelsen's (1979) observation that cleat in the coal developed prior to the Alleghany orogeny but not before diagenesis, it can be concluded that lead and most copper mineralization occurred well after burial but prior to folding.

(5) Although barite occurs along joints that cut mineralized horizons at a few localities (e.g., Jordan North Mountain uranium prospect 1, and near the Marquardt copper occurrence), neither primary copper nor uranium were observed along even those joints in mineralized reduced horizons. Nickelsen and Hough (1967, p. 627) determined that systematic joints, such as the unmineralized N30°E set in the project area, are extensional features and slightly predate Alleghanian folding. As these joints are barren, copper and uranium mineralization probably occurred before the jointing, and hence prior to the Alleghany orogeny. Barite was apparently introduced after the beginning of Alleghanian folding.

(6) The observed carbonaceous plant fragments, freshwater fossil fish remains, *Archanodon* clam fossils, rootlet casts, crossbed textures, and oxidized sediments are consistent with a fluvial, nonmarine environment of deposition of the host rock.

(7) The nearest known igneous rock, a Jurassic Rossville-type diabase dike near Pillow, 70 km (43 mi) to the south of the report area, seems too small and distant to set up a significant hydrothermal system and would be a very unlikely source of uranium.

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[1] Based on the following thicknesses: Catskill Formation, 1,070 m (3,510 ft); Huntley Mountain Formation, 215 m (705 ft); Burgoon Sandstone, 100 m (328 ft); and Mauch Chunk Formation, 100 m (328 ft). Berg and others (1983) show corresponding times of about 366–382 m.y. for the Catskill Formation and 330–366 m.y. for the Huntley Mountain through Mauch Chunk Formations.

(8) The known occurrences do not appear to be related to structures such as fold axes, lineaments, or even faults. Indeed, bedding in the area is subhorizontal, and the rare "faults" (such as at the northeast adit of McCauley prospect 19 and the Birch Still Road reduced zone) are insignificant in size and barren.

(9) Relative to normal sedimentary rocks, most occurrences are strongly enriched in copper and uranium and many in silver, arsenic, and lead as well. A few occurrences are slightly enriched in molybdenum and/or vanadium. The amount of lead greatly exceeds what would be expected from radiogenic sources, making the absence of anomalous zinc especially conspicuous. Based on a few analyses, selenium may also be normal.

(10) The small total amount of metals in even a "good" occurrence (14 kg (31 lb) U_3O_8, 700 kg (1,550 lb) copper, and 2 kg (60 troy oz) silver) does not require enriched source rocks, unusually concentrated ore-transport solutions, or a long, uninterrupted time span for deposition. For example, Rose (1976, p. 1045–1046) relates the distribution of copper occurrences to salt beds in the Upper Silurian or marine influence in the base of the Catskill. Although his comments on cuprous-chloride complexing are well taken, the trace amount of chloride released from the thin marine-transgression sediments near the base of the Catskill during diagenesis may be adequate to account for the small known deposits. Rose (personal communication, 1982) also noted that the same transgressions might provide a convenient source of sulfur via bacterial reduction of marine sulfate.

(11) The large number of occurrences suggests that one should not invoke an unlikely combination of geological events to produce the occurrences.

(12) The presence of apparently similar, unconsumed carbonaceous material and pyrite in both barren and mineralized reduced horizons suggests that "reducing potential" was probably not a limit to the amount of copper or uranium mineralization.

(13) The presence of chalcopyrite and very lean uranium mineralization in the larger reduced lenses versus "chalcocite"[1] and somewhat richer uranium in the smaller lenses further gives the impression that the total amount of mineralization was limited by the source and/or transportation mechanism and not by the lack of a suitable depositional host. Indeed, it seems almost as if most of the larger reduced lenses received the same-sized aliquot of uranium and copper as the smaller.

(14) The relatively constant ratio of Cu/U_3O_8 (see Figure 9, based on median copper and uranium contents of each cluster) for 10 of the 12 clusters suggests that copper and uranium mineralization are closely related and that most of the clusters are of the same fundamental type. Obviously, use of cluster medians has increased the apparent correlation (the correlation coefficient for copper versus U_3O_8 for individual pairs of analyses is only 0.1976), but the use of some such

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[1] The apparent distribution of chalcopyrite versus "chalcocite" is based on examination of only 12 polished sections.

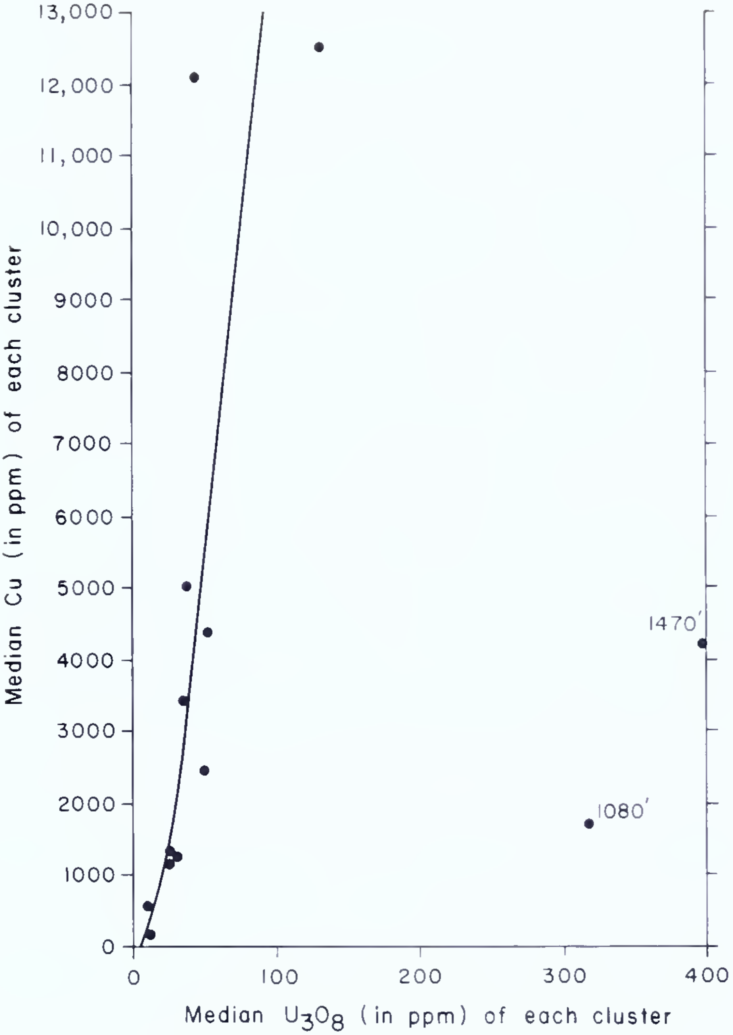

Figure 9. Median copper content versus median U_3O_8 content for each cluster.

technique appears justified based on inhomogeneity and sampling problems (not the least of which is the small number of samples in some clusters).

(15) Based on a plot of median copper versus median U_3O_8 contents of each cluster, 10 of the clusters tend to have a Cu/U_3O_8 ratio of about 100. This compares favorably with typical sedimentary rocks, which have a Cu/U_3O_8 ratio of 11.3 (42/3.7, compilation from Wedepohl's *Handbook of Geochemistry* in Rose and others, 1979). Mechanisms in the Picture Rocks-Sonestown area have therefore enriched copper more efficiently than uranium.

(16) Of the two clusters that do not fit the normal Cu/U_3O_8 ratio for the area, one (Sonestown Nose A at an elevation of 329 m, or 1,080 ft) has a ratio that is based on only two analyses and may therefore be the result of inadequate sampling. The other anomalous cluster

(Old/New U.S. 220 at an elevation of 448 m, or 1,470 ft) has a ratio that is based on five analyses and appears to be real. The median Cu/U_3O_8 ratio of the Old/New U.S. 220 cluster is only 10 (4,100/397), which suggests that it may belong to another class of deposit. This would be in agreement with (17) below.

(17) Plots of the median contents of U_3O_8, copper, arsenic, and lead versus elevation for each cluster (Table 8) suggest a systematic variation. This implies that a variation in source rock and/or host rock was important and, as noted above, that the Old/New U.S. 220 cluster may belong to a separate population.
   - (a) The plot of median U_3O_8 versus elevation for each cluster (Figure 10) has maxima at 329 m (1,080 ft) and 448 m (1,470 ft). By itself, the pattern is not convincing.
   - (b) The corresponding plot for copper (Figure 11) has maxima at 320 m (1,050 ft) and 448 m (1,470 ft). The general correlation with the plot for U_3O_8 suggests that both are probably real.
   - (c) The corresponding plot for arsenic (Figure 12) shows a distinct maximum at 320 m (1,050 ft) superimposed on a baseline that appears to decrease with increasing elevation. The baseline slope may reflect a decrease in arsenic in the Catskill Formation host rock with increasing grain size. Rose and others (1979, p. 550)

Table 8. *Median U_3O_8, Copper, Silver, and Lead Contents of Clusters in the Picture Rocks-Sonestown Area*

(Quantities are in parts per million)

Cluster name	U_3O_8	Cu	As	Pb	Assay samples included
Rock Run	26	1,325	55	90	MHK 741, 745, 748, 758, 759, 760
Fox Run Valley	36	3,475	63	210	MHK 743, 744, 750, 751, 752, 783, 786, 787, 790; PRS-1
Beaver Lake	51	4,375	130	55	MHK 727, 729, 736, 738, 739, 764, 765, 766, 770, 775, 776, 779, 785, 792
Strawbridge	42	4,725	132	1,350	MHK 753, 754, 755, 756, 757, 784
McCauley 22	195	13,000	570	950	MHK 728, 734, 735, 793
Sonestown Nose A	317	1,673	273	133	MHK 740; PRS-9
Sonestown Nose B	44	1,275	48	225	MHK 742, 746, 747, 771, 777, 778
Sonestown Nose C	39	5,000	40	15	MHK 772, 773, 774
Muncy Valley	25	1,150	25	20	MHK 737, 761, 762, 763, 767, 768, 769; PRS-6, 7
Front	11	140	25	835	PRS-3, 4, 5
North Mountain	30	1,260	20	113	MHK 732, 749
Old/New U.S. 220	397	4,100	30	600	MHK 730, 733, 780, 781, 782
Miscellaneous	10	550	155	60	MHK 731, 788, 789, 791, 794; PRS-2, 8
Median of all assay medians	39	1,673	48	133	
Median of individual assays	43	2,950	70	110	

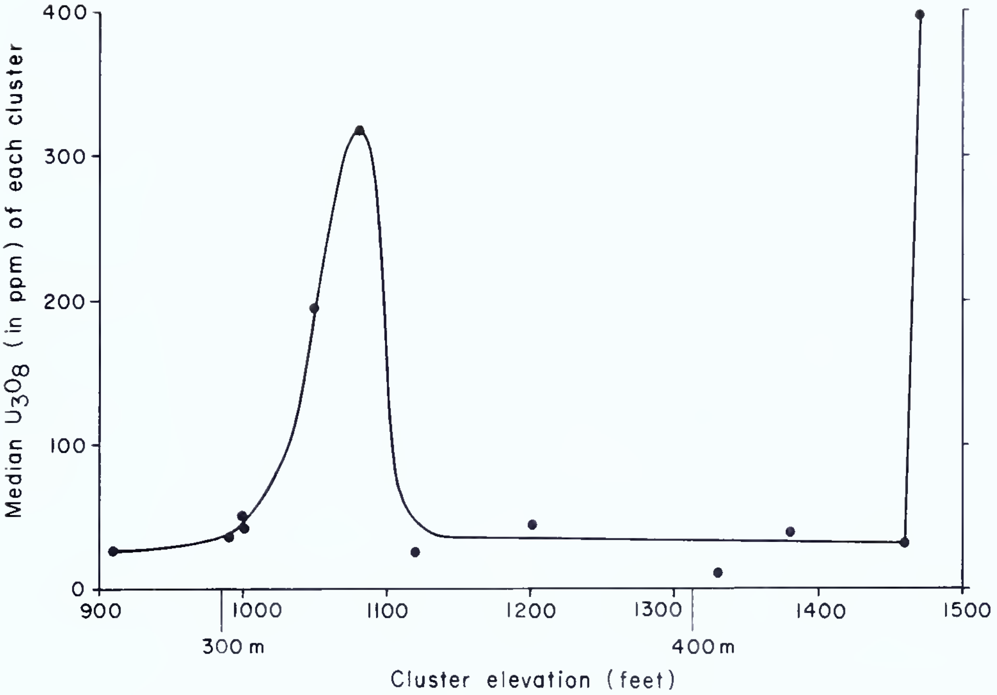

Figure 10. Median U_3O_8 content versus elevation for each cluster.

reported that the median arsenic content is 12 ppm for shales and is only 1.2 ppm for sandstones (see also (16) above). Arsenic also tends to show a strong correlation with the organic content of sedimentary rocks, and it is not unreasonable to assume an inverse relationship between organic content and grain size. The very late position of tennantite in the sulfide paragenesis (indicated by partial rims) and the impermeability of the lower Catskill host suggest that the arsenic stage of mineralization may represent overgrowths from locally derived arsenic that was remobilized during release of connate water.

The above-average arsenic contents of occurrences from 305 m (1,000 ft) to 329 m (1,080 ft) may represent local remobilization of arsenic from fine-grained, organic-bearing sediments that were deposited near a marine-transgression unit such as the one exposed in a borrow pit at an elevation of 325 m (1,065 ft) 1.2 km (0.75 mi) southwest of McCauley prospect 22.

(d) The corresponding plot for lead (Figure 13) shows maxima at 305 m (1,000 ft), 405 m (1,330 ft), and 448 m (1,470 ft), in apparent correlation with U_3O_8 and copper for all but the maximum at 405 m (1,330 ft). The Front cluster at 405 m (1,330 ft) is represented by only three samples, and two of these are from the peculiar Sheets "coal mine."

(18) The median contents of U_3O_8, copper, arsenic, and lead appear to be influenced by the lithology of the host rock (Table 9). Sand-

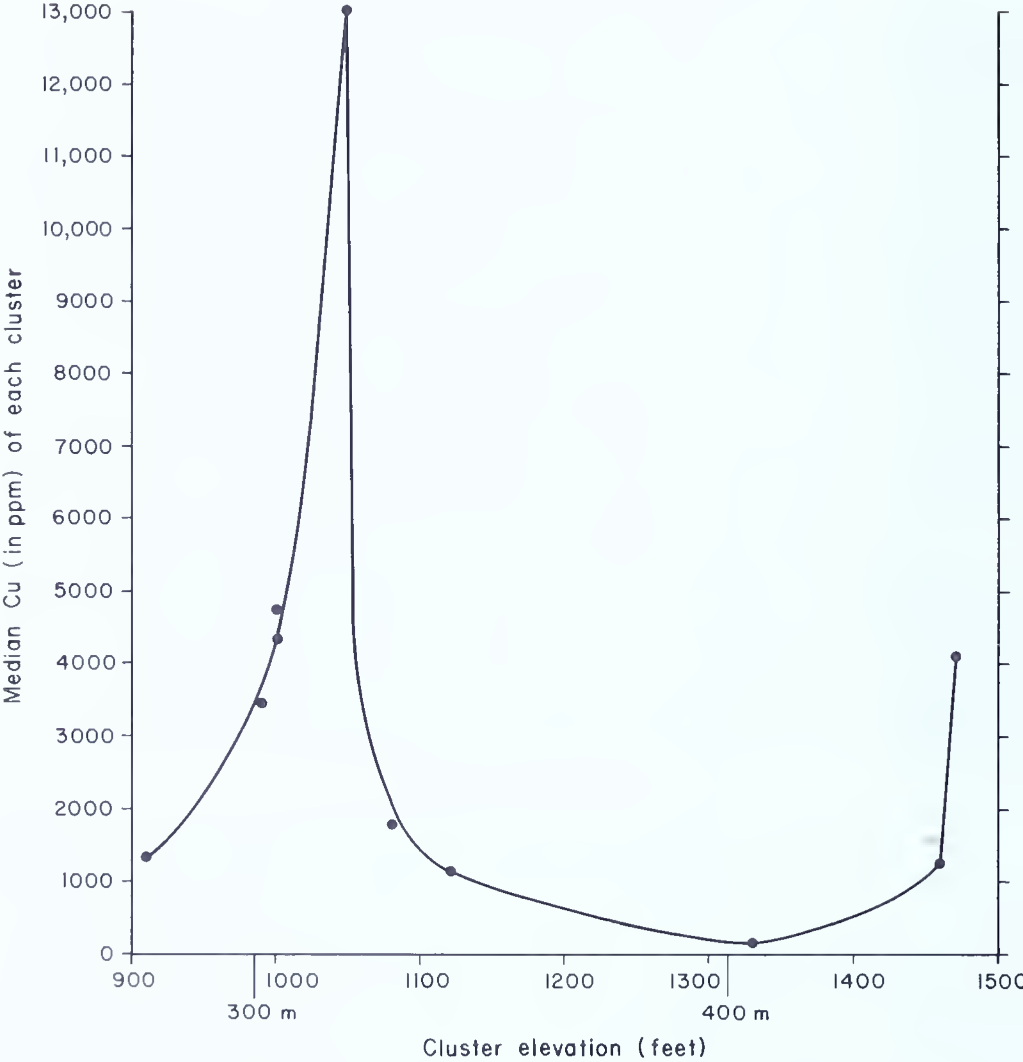

Figure 11. Median copper content versus elevation for each cluster.

stones, and especially those with a "maroon" color, are enriched in U_3O_8 relative to calcareous breccia, siltstone, and shale. Calcareous breccia and "maroon" sandstone are enriched in copper relative to other sandstone, siltstone, and shale. Arsenic does not appear to vary significantly with the lithology of the host rock per se. Lead is found in much greater abundance in sandstone than in calcareous breccia, siltstone, and shale. This, combined with the relatively late position of lead in the paragenesis, suggests that the lithologies other than sandstone may have lost their permeability by the time of lead mineralization.

(19) Muscovite flakes with diameters up to the millimeter range seem to be unusually abundant in mineralized, reduced sandstones in the area. For example, assay samples MHK 737, 745, and 746 and those from the Zimmerman prospect, Carbon County (Smith, 1977a) were

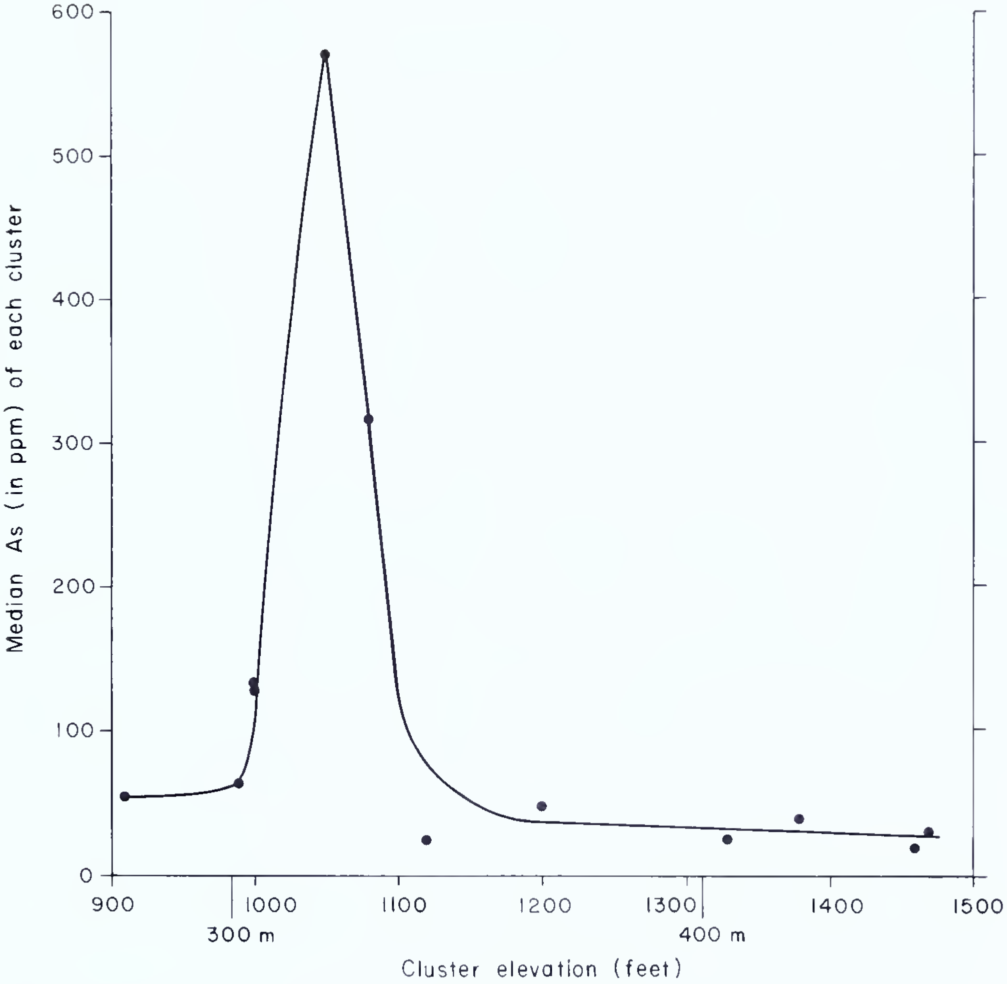

Figure 12. Median arsenic content versus elevation for each cluster.

half-seriously referred to as phyllite during field discussions. It is unlikely that mica enrichment is caused solely by the host being more argillaceous initially, because high-purity shales such as those at the Rock Run copper prospect show little, if any, coarse mica. It also seems unlikely that this coarse mica is strictly detrital if the nearby muscovite-free Reading Prong provenance is accepted. More likely, the sandstones were subjected to a slightly reactive, aqueous phase between deposition and the end of the Alleghany orogeny that either recrystallized finer grained micas or produced substantial overgrowths.

J. H. Barnes (personal communication, October 26, 1981) reported that the mica in samples MHK 737, 745, and 746 is a well-crystallized muscovite, possibly the 3T polytype, and that probably only one mica polytype is present; i.e., the fine- and coarse-grained micas present yield similar diffraction spacings. Major amounts of chlorite, plagioclase, and quartz are also present in these reduced sam-

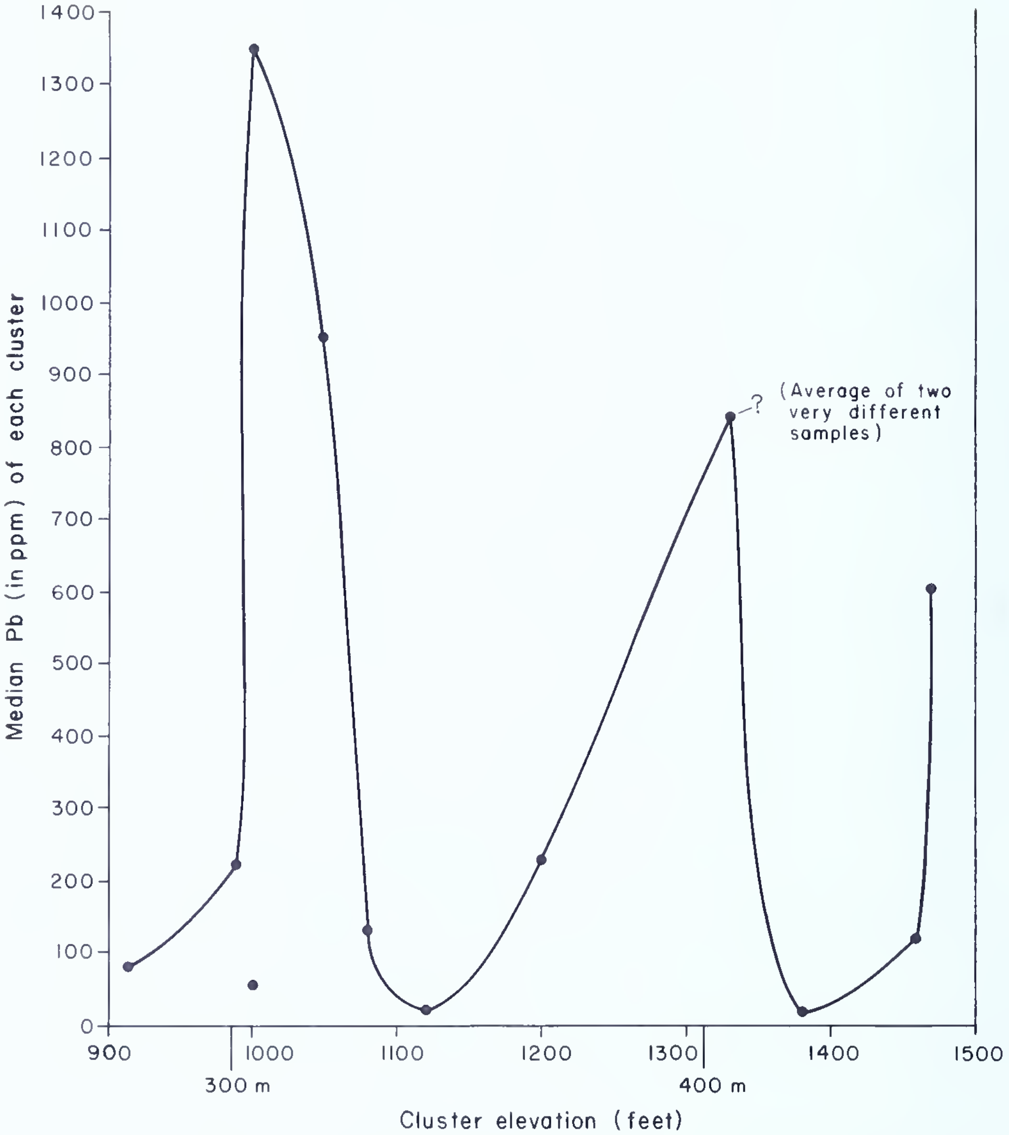

Figure 13. Median lead content versus elevation for each cluster.

ples. Of these, only plagioclase and quartz are essentially detrital, the chlorite very likely being diagenetic.

(20) The transitional color change at the top of a lens and the knife-edge red-gray color change at the base of a channel indicate that the present coloration was usually established during deposition of individual channels. Later reduction caused by the breakdown of plant debris would not be expected to preserve the knife-edge lower color boundary. For example, the change from greenish shale (above) to brownish-red shale (below) at the base of mineralization at McCauley prospect 28 is extremely sharp and parallel to bedding despite the fact that both colors of shale appear to be equally imper-

Table 9. *Median Composition of Copper-Uranium Occurrences in the Picture Rocks-Sonestown Area by Lithology of Host Rock*

(Quantities are in parts per million)

Host-rock lithology	Median U_3O_8	Median Cu	Median As	Median Pb
Calcareous breccia[1]	34	4,150	80	100
Sandstone[2]	55	2,400	78	215
"Maroon" sandstone[3]	250	4,200	40	45
Siltstone and shale[4]	27	1,600	65	80
Median of cluster medians	39	1,673	48	133

[1] Nonmarine calcareous breccia based on both field description and $Ca \geq 2.0$ percent. Seventeen samples include PRS-1, 5; MHK 729, 736, 742, 743, 747, 754, 756, 759, 761, 763, 764, 766, 769, 775, and 777.

[2] Forty-six sandstone samples include PRS-2, 3, 7, 8; MHK 727, 728, 730, 731, 732, 733, 734, 735, 737, 739, 740, 744, 745, 746, 748, 749, 750, 752, 753, 755, 757, 758, 762, 767, 768, 770, 771, 772, 773, 774, 776, 778, 780, 781, 782, 784, 786, 787, 790, 791, 793, and 794.

[3] Eleven "maroon" sandstone samples include MHK 733, 742, 749, 767, 772, 773, 774, 776, 780, 781, and 782.

[4] Thirteen siltstone and shale samples include PRS-4, 6, 9; MHK 727, 730, 738, 741, 751, 760, 779, 785, 792, and 793.

meable. Diffusion seems to be ruled out by the inability of the mechanism to react differently to upper versus lower contacts for all but gas phases.

Considering the essential features, primary mineralogy, and aforementioned observations, it seems unlikely that the copper-uranium occurrences in the lower Catskill in this area developed by a Wyoming-type roll-front remobilization utilizing the hydraulic gradient of the delta. By the time coalification had begun, the fine-grained sediments would no longer have been suitably permeable for near-surface flow. Indeed, no such redox fronts have been found below the relatively coarse upper Catskill Formation in Pennsylvania. Instead, the following models are proposed to explain the copper-uranium mineralization in the Catskill Formation.

Model for the Lower Catskill Formation

The small deposits found in the lower and middle Catskill appear to be related to initial expulsion of moderately to strongly saline connate solutions during diagenetic compaction and/or possibly during early Alleghanian folding. In such a model, small amounts of the solutions would be forced into channels with coarser grained, partly lithified sediments and would tend to migrate both laterally and upward. The uranium and copper in such sediments would then be released during diagenetic crystallization of amorphous hydrous oxyhydroxides to hematite. Deposition of early copper and uranium would occur in reduced sediments containing plant trash, such as in the base of buried channels. Bornite probably formed early and was largely replaced by digenite, then by chalcocite/djurleite. Galena formed later in those sandstones that were still open to solution passage and that initially had sufficient woody debris to produce strong reducing conditions during coalification. Galena formation was triggered by (1) an increase in the lead content of the released connate solutions, possibly related to partial recrystallization of detrital clay minerals into mica or recrystallization of albite under increasing burial metamorphism, and/or (2) a progressively more reducing environment in the host. Before sufficient solutions could replace all of the available carbonaceous material, flow was reduced by some combination of dewatering of the lower Catskill Formation and underlying Lock Haven Formation or restriction of flow via pressure-induced lithification. Finally, tennantite overgrowths formed as partial rims on earlier sulfide composite grains, arsenic-bearing solutions being derived from the enclosing sediments within a few tens of meters. The entire section might have reached a critical temperature for the alteration or recrystallization of a detrital or early diagenetic mineral, which would account for the distinct, late stage of arsenic. This temperature might have been achieved through gradual, continual burial or, possibly, in response to early Alleghanian folding. In general, the authors envision a relatively localized, closed system responding to advancing burial metamorphism, in which there was a time limit for the duration of mineralization within each stage.

Rose in Sevon and others (1978) noted that (1) chloride might also be available during deposition of the Devonian-Mississippian transition zone between the Catskill Formation and the Burgoon Sandstone (Huntley Mountain Formation of Berg and Edmunds (1979), which includes the marine conglomerate at Cedar Run); (2) the oxidizing portion of the Eh-pH stability field for soluble cuprous chloride complexes overlaps that for soluble uranyl complexes so that uranium and copper mineralization can be accomplished by one process; (3) bacterial reduction of soluble sulfate to H_2S and related species capable of precipitating copper would occur near accumulations of plant debris. Taken with the observations of the present study, these and other theoretical considerations of Rose seem to yield a relatively simple genetic model.

Model for the Upper Catskill Formation

For deposits in sandstones that are low in copper, such as those in the Old/New U.S. 220 cluster, a model need neither be severely restricted by impermeability due to a fine-grained host nor related to marine influence. The greater ratio of U_3O_8/Cu requires relatively less chloride for copper transport. The greater absolute amount of U_3O_8 requires a more efficient process or one of greater duration. For these deposits, a modified roll-front model, such as the one derived by Schmiermund (1977) and Rose (Sevon and others, 1978, p. 32–36) seems appropriate. In their model, oxidizing uraniferous groundwater moves downslope in a delta complex through a conglomeratic sandstone aquifer and deposits uranium in reducing environments. Unlike the model for the lower Catskill, such a system is relatively open (to introduction of uraniferous solutions from larger volumes of source rock) and would not be as quickly sealed off by burial metamorphism.

Evidence that the Old/New U.S. 220 cluster belongs to a different population of occurrences is tenuous at best, but is believed to be supported by the following: (1) a coarser than average grain size, especially for the Bench Mark 359 uranium-copper-lead occurrence; (2) a median U_3O_8/Cu ratio for the cluster that is an order of magnitude higher than the ratio for other clusters (Figure 9); (3) relatively high absolute amounts of U_3O_8 compared with amounts for most of the district; and (4) a suggestion of higher vanadium (MHK 730, 733, 780, and 782), selenium (MHK 780 and 782), and molybdenum[1] (MHK 730, 780, 782, and trace wulfenite, $PbMoO_4$, near the site of MHK 733) than in most other clusters.

These data for vanadium, selenium, and molybdenum suggest relative enrichment in elements that are typically remobilized and concentrated in redox roll-front deposits, as pointed out by Schmiermund (1977) for the Penn Haven Junction example. Vanadium enrichment there is confirmed by mineralogic observations by the authors.

DESCRIPTIONS OF INDIVIDUAL OCCURRENCES

The present study of copper-uranium occurrences in the Beaver Lake district was begun in the summer of 1978 to provide basic information for the 43rd Field Conference of Pennsylvania Geologists. Both the topic for the Field Conference and the present study were suggested by the Director of the Pennsylvania Geological Survey, Arthur A. Socolow. Socolow had become acquainted with the occurrences in the area when he accompanied McCauley during the field work for McCauley's (1961) report, and suggested that the unusually large number of occurrences warranted further study. Hence, following the Field Conference in October 1978, the authors proceeded to briefly study each of the known and readily locatable occurrences in the Picture Rocks and Sonestown quadrangle areas, which enclose the Beaver Lake district. Hoff had collected and studied hand samples from some of the larger prospects when they were active during the late 1950's.

In general, field work proceeded first on the 13 occurrences reported by McCauley (1961, p. 60–64) and the eight[2] reported by Klemic (1962, p. 277–278). A car-borne survey using a Mt. Sopris scintillometer that became available to the project in March 1979 yielded six new occurrences plus shows, and discussions by Hoff with former prospectors and landowners yielded approximately 15 additional prospects and occurrences. Finally, geologic intuition, aid from mineral-exploration companies, and miscellaneous sources yielded 16 more. Thus, a total of approximately 55 occurrences and prospects is described in this report, a 300 percent increase over the total of 18 in this area reported by McCauley (1961) and Klemic (1962).

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[1] See Appendix 3, Table 77.

[2] Including three occurrences reported by both McCauley and Klemic.

Each of the authors spent 46 days in the field area between October 1978 and April 1980, the bulk of the work being completed by July 1979. The authors did most of the field work together, but some tasks were done separately, such as pursuing data from prospectors (Hoff) and the scintillometer car-borne survey[1] (Smith).

This study evolved as new information became available. The amount of field work originally planned was increased for several reasons: (1) the published locations for some McCauley occurrences (e.g., prospects 22 and 23) were obtuse; (2) more prospects were found than originally anticipated; (3) a car-borne gamma-ray survey was added when a scintillometer became available; and, especially, (4) 72 true channel samples (Figure 14) were cut by the authors when U_3O_8 assays and semiquantitative trace-element determinations became available through the Bendix Field Engineering Corporation, Pittsburgh. Typically, each channel sample required many man-hours of crack hammer and chisel work.

Because most of the field work was site specific and reconnaissance was restricted to the road network, it is likely that there are many more occurrences in the area than are described in this report. Suggestions for further study are given in "Recommendations," but it should be noted here that minimal examination of favorable horizons was conducted more than 100 m (300 ft) laterally from the reported occurrences. It is believed that the larger prospects and examples of each of the typical deposit types have been found and described. A point of diminishing returns (in terms of new occurrences found per day) was not reached, but all of the obvious leads were utilized.

FORMAT OF DESCRIPTIONS OF OCCURRENCES

Fifty-five occurrences are described in this report. Most descriptions cover a single copper-uranium occurrence. Exceptions, however, have been made where two or more very similar mineralized lenses occur in the same outcrop or immediately along strike and were not divided by previous workers. For example, the single description of McCauley prospect 22 includes the northwest adit, 19.2-m site, 10.2-m site, 6-m site, and southeast adit.

In order to facilitate presentation of the data, the Beaver Lake district (here used synonymously with the area of the Picture Rocks and Sonestown quadrangles) has been divided into 10 clusters of limited geographic and stratigraphic extent. Occurrences not fitting into any of these clusters have been placed in the category of "Miscellaneous Occurrences." The cluster names and approximate elevations as well as the member names and their elevations are presented in Table 10. The individual occurrences are shown on Plate 1. Typically, the clusters have been named after a prominent occurrence or geographic feature and include a number of occurrences from the same or a similar stratigraphic horizon. The clustering is believed to be real,

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[1] Described earlier under "Clustering."

Table 10. *Elevations and Members of Clusters of Copper-Uranium Occurrences in the Picture Rocks-Sonestown Area*

Cluster name	Approximate elevation of cluster[1] (m)	(ft)	Member of cluster (approximate elevation, in feet)
Rock Run	277 ± 12	910 ± 40	McCauley prospect 28 (870), McCauley prospect 28-1/2 of Mahar (950), Rock Run Church copper prospect (910), and Rock Run uranium occurrence (870). Drill holes UGER-10 (920), -15 (980?), and -16 (950).
Fox Run Valley	302 ± 18	990 ± 60	Edkin uranium-copper prospect (950), Fort Sumpter uranium prospect (1,050), McCauley prospect 23 (990), McCauley prospect 24 (930), McCauley prospect 24-1/2 of Mahar (900?), Old Copper open pit (1,090?), Old Farm uranium-copper occurrence (980), and Tivoli Overlook copper-uranium occurrences 1 (990) and 2 (980).
Strawbridge	305 ± 9	1,000 ± 30	Strawbridge copper prospect 1 (980), Strawbridge copper prospect 2 (1,020), Strawbridge uranium-copper lens (1,020), Strawbridge intermediate point (1,000), and Strawbridge Northwest uranium-copper lens (970).
Beaver Lake[2]	305 ± 30	1,000 ± 100	Copper Hollow North Frost Wedge copper-uranium occurrence (1,010), Copper Hollow 1 uranium-copper prospect (1,010), Copper Hollow 2 prospect (990), Copper Hollow 3 uranium-copper prospect (McCauley prospect 20) (980), Copper Hollow 4 prospect (1,010), Copper Hollow 5A and 5B prospects (1,020), Copper Hollow 6 prospect (1,020), Copper Hollow 7 prospect (1,050), Copper Hollow 8 prospect (1,020), Hamilton-Jordan copper-uranium prospect (1,100), Jordan Sawmill adits (980), Klemic locality 8 (910), Klemic locality 9 (900), McCauley prospect 18 (980), McCauley prospect 19 (980), McCauley prospect 21 (1,040), and upper limonitic zone (980).
McCauley 22	320 ± 6	1,050 ± 20	Edler Drive (1,070), Edler Lake uranium-copper occurrence (1,030), and McCauley prospect 22 (1,070).
Sonestown Nose A	329 ± 12	1,080 ± 40	McCauley prospect 29 (1,040), Klemic locality 13 (1,110), and Mosey Glen uranium-copper occurrence (1,100).
Sonestown Nose B	366 ± 9	1,200 ± 30	Sonestown Nose uranium trench of Gill-Jordan (1,230), Middle Catskill Reduced Zone uranium-copper occurrence (1,170), and Sonestown Nose Northwest uranium-copper occurrence (1,230).
Sonestown Nose C	421 ± 6	1,380 ± 20	Sonestown Nose Reduced Cap copper-uranium zone (1,380).

Table 10. *(Continued)*

Cluster name	Approximate elevation of cluster[1] (m)	(ft)	Member of cluster (approximate elevation, in feet)
Muncy Valley	341 ± 15	1,120 ± 50	Jordan borrow pit (1,140), Klemic locality 12 (1,070), McCauley prospect 26 (1,160), and Shultz copper adit (1,120).
Front	405 ± 9	1,330 ± 30	Sheets "coal mine" uranium-lead occurrence (1,360) and Upper Catskill Reduced Zone copper occurrence (1,310).
North Mountain	445 ± 6	1,460 ± 20	Jordan North Mountain uranium prospect 1 (1,450) and Jordan North Mountain uranium prospect 2 (1,470).
Old/New U.S. 220	448 ± 6	1,470 ± 20	Bench Mark 359 uranium-copper-lead occurrence (1,460), New U.S. Route 220 uranium-copper occurrences (1,480), and Old U.S. 220 culvert (1,410?).
Miscellaneous occurrences	244 to 524	800 to 1,720	Allegheny Ridge copper-uranium occurrence (1,720), Hill Family Reduced Zone copper and uranium occurrences (1,180), Marquardt copper occurrence (1,590), Marquardt uranium occurrence (1,580), McCauley prospect 17 (1,190), and Tivoli adit (800).

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[1] Elevations are utilized as a substitute for stratigraphic positions in this region of low dips and poorly defined folds.

[2] Bedding dips measurably to the north in Copper Hollow, complicating the substitution of elevation for stratigraphic classification.

except for the rather spread out Muncy Valley cluster. The occurrences within one cluster are described in a separate section. The sections are arranged in order of increasing elevation of the cluster described. The arrangement within each section is alphabetical.

In a few cases, the authors located occurrences that were too small to justify detailed sampling and description. They are tabulated in Appendix 2 and noted on Plate 1 with the symbol "X." The minute Allegheny Ridge copper-uranium occurrence was described to document mineralization in the uppermost Catskill Formation/lowermost Huntley Mountain Formation.

Where possible, the authors have used formerly established names for occurrences. The prospect and locality numbers used by McCauley (1961) and Klemic (1962) have been retained. Previously undescribed occurrences have been named after the owner, prospector, or a prominent local geographic feature. For most, the name indicates whether copper and/or uranium are important. Some of the occurrences have been assigned alternate names, and these names are given in parentheses.

Because of the abundance of small occurrences and prospects in Copper Hollow, 1 km (0.6 mi) southwest of the Beaver Lake outlet, the names "Copper Hollow prospect" 1 through 8 have been assigned. Number 1 is located nearest the normal access route into the hollow and the others are numbered sequentially counterclockwise around the hollow.

The descriptions of the individual occurrences are arranged according to the following subjects: 1. Location; 2. Assays and Trace-Element Analyses; 3. Mineralogy; and 4. Geologic Description.

1. LOCATION:
    (a) The name of the owner of each occurrence is listed where known, based on personal communications with residents. This information has *not* been verified by search of courthouse records. Although some owners were unintentionally vague about their boundaries, the authors have no reason to doubt any of their statements. Intrafamily transfer of property seems to be common in the area, but should not cause serious confusion.

        The distance and general bearing to several permanent topographic features or semipermanent structures are given. Where feasible, the elevation has been estimated to the nearest 10 feet (3 m) from the topographic map or by hand-leveling to a known elevation. Larger errors are probable for occurrences in remote areas (such as McCauley prospect 22), along new roads not shown on the map (such as New U.S. Route 220 uranium-copper occurrences), or in dense forest and recently timbered areas (such as the Strawbridge area). Township and county names are included.
    (b) The latitude and longitude have been estimated to the nearest second. Most are accurate to better than ± 50 m (160 feet). This should help users avoid having to repeat the time-consuming searches that were conducted for the present study.
2. ASSAYS AND TRACE-ELEMENT ANALYSES: Quantitative trace-element analyses for arsenic, copper, uranium, and lead, as well as semi-

quantitative estimates of several other elements, were obtained for samples from each described occurrence. Arsenic was determined colorimetrically, copper and lead by atomic absorption of a hot perchloric acid extraction, and uranium by a fluorimetric method. For the MHK series (727–794), uranium analyses and semiquantitative estimates for other elements based on an inductively coupled plasma (I.C.P.) procedure were provided by the Bendix Field Engineering Corporation in conjunction with their Williamsport 1° by 2° project. The Pennsylvania Geological Survey funded similar fluorimetric and emission spectrographic commercial analyses for the PRS series (1–9) and all quantitative arsenic, copper, and lead analyses.

Based on the I.C.P. estimates, a few samples were also checked for silver, molybdenum, selenium, and vanadium by commercial trace-element analyses. All usable[1] analyses are presented in Appendix 3, whereas section 2 of each description includes only the data for copper and uranium and, where substantially enriched, for related elements.

For most of the occurrences, the analyzed sample or samples were obtained from a continuous channel cut using a crack hammer and chisel (Figure 14). Most required several hours of labor. Such channels were cut perpendicular to bedding with the intention of including the entire mineralized thickness, not only the high-grade portion. Upper and lower limits were typically defined with a Geiger counter using a cutoff of about 0.07 "mR/hr"[2] or by the disappearance of visible copper mineralization. The sampled intervals are described as part of the individual stratigraphic descriptions.

The vertical channel samples were usually cut through the approximate center of a lens, where the mineralization tends to be somewhat thicker and more intense. Local enrichments, such as those in the larger, individual carbonaceous limbs, were avoided. It is possible that many assays done during the 1950's boom were run on such high-graded limb specimens. The outer centimeter or so of weathered rock was removed prior to collecting in an effort to avoid extreme cases of enrichment or depletion. In general, it is believed that the analyzed samples are moderately representative of what could be recovered by selective mining if the grade and thickness warranted it.

For McCauley prospects 17, 18, and 19, as well as the Old Copper open pit and Strawbridge copper prospect 2, composite dump samples consisting of a few kilograms of small chips of excavated, reduced rock were collected. They should be roughly comparable in grade to the values that would have been obtained from channel samples if the section had still been accessible.

3. MINERALOGY: This section contains a list chiefly of the relative amounts of "introduced" (versus normal host-rock) major, minor, and trace minerals. The list includes primary and secondary minerals as well as "ore" and gangue minerals, with brief descriptions of most. Almost

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[1] Improbable results for arsenic, tin, tungsten, and zinc have been omitted.

[2] See page 54 for discussion of "mR/hr."

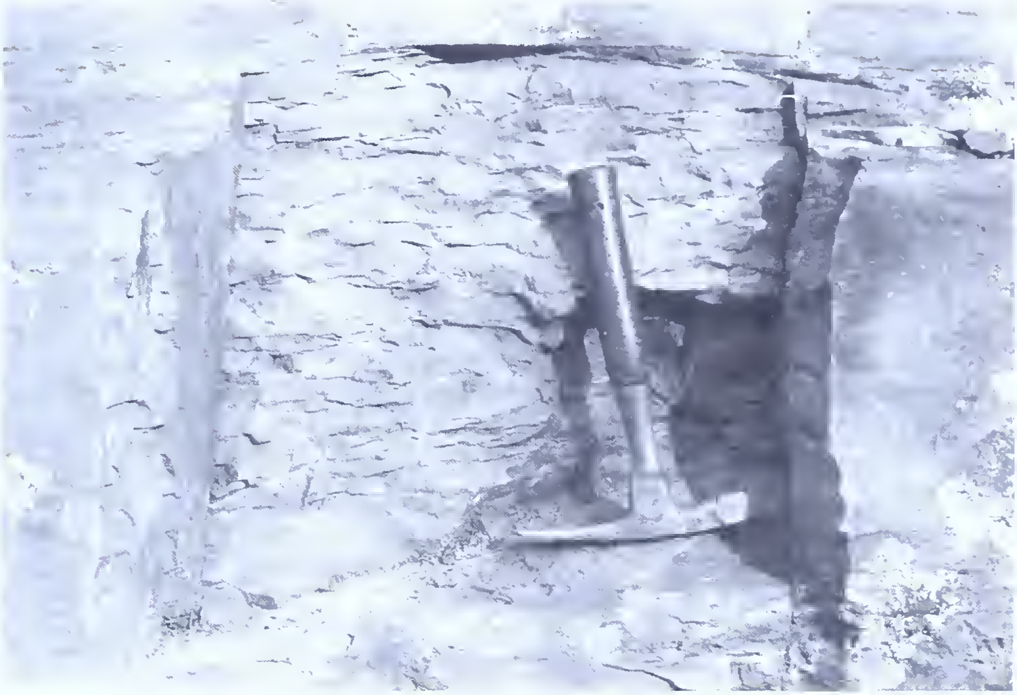

Figure 14. Massive sandstone bed in which a channel sample has been cut to obtain a representative sample for assays, McCauley prospect 29.

all of the rare minerals have been identified by X-ray powder diffraction and by either qualitative X-ray fluorescence scans or optical properties determined from oil immersions or polished sections.

A question mark in parentheses following the name of a mineral species indicates that the identification is uncertain. As previously noted, "chalcocite," where enclosed in quotation marks, is a field term denoting chalcocite and/or djurleite, but generally not the distinctly bluer digenite.

4. GEOLOGIC DESCRIPTION: This section includes a description of the outcrop, exposure, or workings and plan maps of each of the significant adits. Where obtainable, the length and thickness of mineralization are given. Except as individually noted, the known occurrences have little economic potential. For those occurrences having a moderate lateral extent, any changes are briefly described based on measurements taken along a stretched meter tape. The locations for the channel-sample and stratigraphic-description sites are also given. Typically, such measurements are taken from a distinctive feature at one end of the mineralized interval or the center line of an adit's roof at the entrance.

   Most bedding data (Plate 1) represent the median of three measurements on surfaces that were as free from apparent crossbedding effects as possible. Thus, most measurements were obtained on siltstones and, in a few cases, laminated or flaggy sandstones. Low dips prevail throughout the portion of the quadrangles covered by the Catskill Formation, necessitating the use of a low-dip method of measurement. Joint data are also medians. Only the most pronounced joint set was measured at each occurrence; excellent surfaces were commonly available.

The term "calcareous breccia," as used in this report, is a sedimentary, calcareous channel-lag deposit composed of oxidized and reduced shale chips, carbonaceous plant fragments, and phosphatic fish remains, in a somewhat crystalline limestone matrix. It forms the base of most mineralized lenses and typically contains uranium in the plant fossils and copper, as sulfides, in both the same fossils and disseminated in the calcite matrix (see also the "Essential Features" section, p. 30, and the "Genesis" section, p. 36). A. W. Rose and A. T. Smith (personal communication, 1982) noted that such calcareous material probably represents caliche fragments released from overbank muds.

Stratigraphic descriptions of each mineralized horizon and, where accessible, the adjacent oxidized beds, are presented for each occurrence that was channel sampled. Colors were determined using a standard rock-color chart (Goddard and others, 1975).

Estimates of radioactivity are given to define the limits of mineralization. Note that measurements are given as "milliroentgens per hour ("mR/hr") even though the beta shields on the Geiger counters were open, meaning that true mR/hr readings were not obtained. The shields were open to obtain better sensitivity and reproducibility over time. Normally, under such conditions, counts per second (cps) are reported. In the case of the instruments used, however, readings of "mR/hr" so taken were found to be reproducible and comparable from one Geiger counter to another, whereas readings of counts per second were not. All "mR/hr" data were obtained with a Geiger counter. Professional calibration of the main instrument indicated that it yields extremely precise and accurate measurements down to 1.5 mR/hr, the lowest calibration source checked. Below about 0.2 "mR/hr," the statistics appeared to degrade substantially. In the range of 0.05 to 0.10 "mR/hr," the reproducibility is typically ±0.01 to ±0.02. The reported measurements were made after exposing a fresh face and with the probe in contact with the outcrop. Underhangs, crevices, and extremely local fossil "limb" accumulations were avoided wherever possible. A small lead plate and the head of the sledge hammer were also used to provide partial shielding in such areas. No corrections were made, however, for radon accumulation in the rear of the longer, unvented adits such as at the Shultz copper adit and Klemic locality 8.

After March 1979, a Mt. Sopris Model SC–132 scintillometer was available to the project. It contains a 3.8- by 3.8-cm (1.5- by 1.5-in.) NaI(Tl) detector, and the data are reported in counts per second. All data on counts per second were obtained with this instrument. When held about a meter (3 ft) above the ground, it yielded 125 ± 50 cps for "normal" rocks and ≥ 200 cps for mineralized areas. Readings reported along meter-tape traverses were taken with the instrument in contact with the rock or soil surface.

A differential-gamma-scanner method (whereby two measurements are taken on a flat surface with and without a lead shield plate and the differences noted) for estimating radiometric equivalent to U_3O_8 in parts per million was tried with the Mt. Sopris instrument. Comparison with actual channel-sample assays suggests that the results were more useful than raw scintillometer or Geiger counter readings. For the area studied, the results of the differential-gamma-scanner method seem to be accurate to ±50 percent after dividing by two (to correct for typical radiometric equilibrium effects in the region?)

Most of the field effort was directed toward locating and sampling the occurrences. This and the fact that each author spent a total of only 46 days in the field, of which much time was spent in travel and investigating leads, suggest that a detailed study of any of the occurrences should result in an improvement upon the data reported here, and that errors in the authors' work will certainly be found.

ROCK RUN CLUSTER

McCauley Prospect 28

1. LOCATION:
   (a) The prospect is located on the Jack G. Craft property on the northwest side of Rock Run Road, 0.69 km (0.43 mi) northeast of the Sullivan-Lycoming County line and 0.34 km (0.21 mi) northeast of the intersection with Golder Hill Road, Shrewsbury Township, Sullivan County. The adit entrance is located 6 m (20 ft) northwest of the road center and 29 m (95 ft) northeast of the Rock Run uranium occurrence (p. 62), all at an approximate elevation of 265 m (870 ft). This area is 3.3 km (2.05 mi) northeast of Glen Mawr.
   (b) Latitude: 41°20′20″N
   Longitude: 76°37′57″W
2. ASSAYS: A 75-cm (30-in.) channel sample of carbonaceous, gray sandstone (which includes the 13-cm- (5-in.-) thick lower, plant-fragment-rich portion of the 1.15-m (45-in.) unit intersected by the adit roof) contains 53 ppm U_3O_8, 410 ppm copper, about 75 ppm molybdenum, and 0.37 percent lead. A 15-cm (6-in.) channel sample of calcareous breccia from beneath the sandstone contains 10 ppm U_3O_8 and 2,950 ppm copper. A 25-cm (10-in.) channel sample of greenish-gray shale (sample was cut off above the first red laminae) from beneath the calcareous breccia contains 5 ppm U_3O_8 and 1,600 ppm copper. The uranium tends to be relatively enriched in carbonaceous sandstone, whereas the copper tends to be enriched in the calcareous breccia. See samples MHK 758–760, Appendix 3.
3. MINERALOGY:
   (a) Major: Goethite as "limonite," with large carbonaceous plant fragments in reduced sandstone.
   (b) Minor: Malachite in calcareous breccia and especially as thin coatings on bedding-plane partings in reduced shale.

(c) Trace: Tiny, rare grains of weathered "chalcocite" and bornite, and "apatite" as phosphatic fish remains in calcareous breccia; azurite and chrysocolla in calcareous breccia. Rare grains of cerussite occur together with the "limonite" in reduced sandstone.

4. GEOLOGIC DESCRIPTION: The occurrence consists of a 2.2-m- (87-in.-) thick reduced lens which was prospected for copper more than 50 years ago via an adit (Figure 15). The adit is 5.7 m (18.7 ft) long, 1.3 m (4.3 ft) wide, and 1.4 m (4.6 ft) high, and trends N18°W.

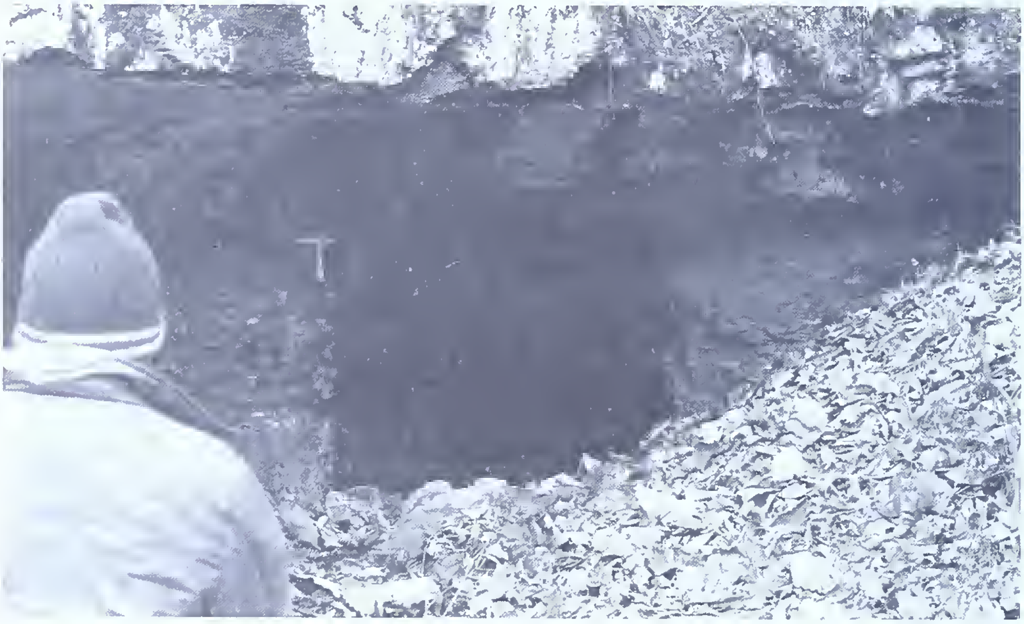

Figure 15. Massive gray sandstone forms the roof of the adit at McCauley prospect 28 at the head of the hammer. Note the rectangular cross section at the entrance. The lowest 13 cm (5 in.) of this slightly radioactive bed was included in the uppermost channel sample.

The stratigraphy exposed on the east side of the adit entrance is described in Table 11. The section exposed near the back of the adit consists of more than 40 cm (16 in.) of pyritic(?) and micaceous, gray sandstone containing very abundant carbonaceous plant fragments up to 40 cm (16 in.) in length underlain successively by 25 cm (10 in.) of gray siltstone, 10 cm (4 in.) of gray calcareous breccia, 35 cm (14 in.) of gray siltstone, and more than 10 cm (4 in.) of red, micaceous siltstone.

This relatively thick reduced zone is at approximately the same horizon as the Rock Run uranium occurrence, the Rock Run Church copper prospect, and McCauley prospect 28-1/2 of Mahar (1978). This horizon is on the order of 250 m (820 ft) beneath the overlying Huntley Mountain Formation. The moderately high lead and molybdenum contents at both McCauley prospect 28 and the Rock Run uranium occurrence feebly suggest a genetic relationship.

Table 11. *Stratigraphic Section of Catskill Formation Rocks at McCauley Prospect 28*

Exposure is on the east side of the prospect, 0.73 km (0.45 mi) northeast of Rock Run Church.

Thickness (cm)	Radioactivity ("mR/hr" ±0.02)	Lithologic description
>100	.03-.04	Grayish-red (10R4/2), fine-grained, micaceous sandstone.
115	.03-.08	Medium-light-gray (N6), fine- to medium-grained, micaceous sandstone. Includes a 10-cm sandstone bed at the base which contains abundant large carbonaceous plant fragments and has a radioactivity of 0.15 "mR/hr." This somewhat radioactive bed forms the roof of the adit. The lowest 13 cm is included in the 75-cm-thick assayed sandstone sample.
~20	.15 avg.	Medium-light-gray (N6), very thin bedded, micaceous siltstone-sandstone containing very abundant carbonaceous plant fragments.
42	.07	Medium-gray (N5), very micaceous, interbedded siltstone and fine-grained, crossbedded sandstone containing very abundant, large carbonaceous plant fragments. Includes 5 cm of dark-greenish-gray (5GY4/1) shale at the base.
15	.06	Medium-light-gray (N6) calcareous breccia with malachite staining and trace "chalcocite" and bornite. Chrysocolla traces in the back of the adit. Phosphatic fish remains typically rimmed by malachite. Channel sample includes 1-cm-thick gray shale-siltstone in the middle.
30	.06	Dark-greenish-gray (5GY4/1) shale. Malachite on bedding partings.
>35	.05	Brownish-gray (5YR4/1) to grayish-red (5R4/2) shale and mudstone.

The maximum localized radioactivity of 0.2 "mR/hr" was observed at one spot in the roof of the adit, whereas the average in the adit was only 0.07 "mR/hr." Because of this and the low U_3O_8 assay values, the adit area itself is believed to be of no economic significance.

McCauley Prospect 28-1/2 of Mahar

1. LOCATION:

   (a) The main mineralized outcrop is on the northwest side of Rock Run Road, 1.57 km (0.98 mi) northeast of Rock Run Church. This is 69 m (226 ft) southwest along Rock Run Road from the center of the bridge over Rock Run on the Picture Rocks-Sonestown quadrangle boundary. The occurrence is 5.8 m (19 ft) northwest of the center of the road and at the same elevation as the road (290 m, or 950 ft), Shrewsbury Township, Sullivan County.

(b) Latitude: 41°20′41″N
Longitude: 76°37′32″W

2. ASSAYS: A 77-cm (30-in.) channel sample of gray shale containing trace malachite yields 2 ppm U_3O_8 and 1,050 ppm copper. Where the channel sample was discontinued because of flooding of the cut, the lower limit of mineralization had not been reached. See sample MHK 741, Appendix 3.
3. MINERALOGY:
   (a) Major: None.
   (b) Minor: Malachite as thin coatings and radiated groups of lathlike acicular microcrystals on bedding partings.
   (c) Trace: "Apatite" as phosphatic fish remains with intergrown malachite in weathered calcareous float, and barite(?) in float.
4. GEOLOGIC DESCRIPTION: The occurrence of copper and uranium here was first noted by Mahar (1978, p. 22), who reported that he found it by extrapolating from the mineralized horizon at McCauley prospect 28. Mahar's (1978, p. 116) Figure 32 may be a sketch of the mineralized zone, in which case his WR-6 rock sample, which has 2.8 ppm uranium and 240 ppm copper, may be from the same lens as the channel sample of the present study. Interpretation is difficult because Mahar omitted the WR series samples from his lithology and sample-location table, and Rock Run Road was widened between the time of Mahar's investigation and the present study. If, however, Figure 32 of Mahar does refer to McCauley prospect 28-1/2, then there was an exposure of calcareous breccia containing 490 ppm copper and 16 ppm uranium beneath reddish sandstone about 40 m (130 ft) southwest(?) of the presently exposed copper mineralization. Mineralized calcareous breccia float along the southeast berm of the road substantiates Mahar's sketch.

Table 12. *Stratigraphic Section of Catskill Formation Rocks at McCauley Prospect 28-1/2 of Mahar*

Exposure is on the northwest side of Rock Run Road, 69 m (226 ft) southwest from the center of the bridge on the Picture Rocks-Sonestown quadrangle boundary.

Thickness (cm)	Radioactivity ("mR/hr")	Lithologic description
185	.02	Grayish-red (10R4/2), fine-grained, micaceous sandstone. Laminated to thin bedded. The color is between grayish red (5R4/2) and blackish red (5R2/2) near the bottom.
11	.03	Between grayish red (5R4/2) and blackish red (5R2/2). Shale.
>77	.03	Greenish-black (between 5G2/1 and 5GY2/1), laminated to thin-bedded, interbedded shale, siltstone, and fine-grained sandstone containing trace calcareous breccia. This assayed unit contains minor malachite films and coatings throughout.

The stratigraphy at the presently exposed, 12-m- (39-ft-) long mineralized portion of the outcrop is described in Table 12. The pronounced joint in the massive sandstone above the gray shale that was sampled strikes N26°E and dips 90 degrees. The bedding of this gray shale strikes approximately N33°E and dips 7°NW.

Trace malachite occurs in a 10-cm- (4-in.-) thick gray siltstone lens beneath calcareous breccia at the base of the first major outcrop above the bridge. The bearing from the center of the bridge over Rock Run to this lens is N77°W on an incline of 18 degrees.

Without testing the unexposed base of the main reduced zone, the area of McCauley prospect 28-1/2 of Mahar cannot be properly evaluated.

Rock Run Church Copper Prospect

1. LOCATION:
   (a) The prospect is located on the Jack G. Craft property on the northeast edge of Ticklish Rock Road about 110 m (360 ft) northwest of Rock Run Church (Plate 1). It is 5.5 m (18 ft) northeast of the center of the road and 14.3 m (46.9 ft) east (topographic map is in error) of the center of the unnamed south-flowing tributary to Rock Run, Shrewsbury Township, Sullivan County.
   (b) Latitude: 41°20′11″N
   Longitude: 76°38′26″W
2. ASSAYS: A 20-cm (8-in.) channel sample of weathered, malachite-rich carbonaceous sandstone contains 43 ppm U_3O_8, 3.05 percent copper, and about 84 ppm (2.5 troy oz/ton) silver. See sample MHK 748, Appendix 3.
3. MINERALOGY:
   (a) Major: Malachite as stellated crystalline aggregates exhibiting concentric color banding embedded in chrysocolla and as coatings. Chrysocolla exhibits reversible blue to off-white color with dehydration.
   (b) Minor: None.
   (c) Trace: "Apatite" as phosphatic fish remains.
4. GEOLOGIC DESCRIPTION: The original prospect appears to have consisted of a small, approximately N60°E trending trench which had a width of approximately 1.6 m (5.2 ft) at the depth of the mineralized horizon. The original trench is essentially obliterated, but a temporary excavation made during the present study along the base of the N40°W-trending outcrop face proved a 5-m- (16-ft-) long zone of copper mineralization. The average radioactivity along this mineralized horizon is 0.06 "mR/hr." A second trench, perpendicular to the first, located 3.6 m (11.8 ft) farther southeast toward Rock Run Church is barren of copper and uranium. Optimistically assuming that the lens dimensions are 5 by 5 by 0.2 m (16 by 16 by 0.7 ft) and the grade is 43 ppm U_3O_8, up to 5 kg (11 lb) of U_3O_8, 380 kg (838 lb) of copper, and about 10 kg (322 troy oz) of silver might be present. Because of the occurrence of three other small shows at approximately the same stratigraphic interval along

Rock Run, it seems likely that additional shows could be found in this area.

The stratigraphy of the section that was temporarily exposed is summarized in Table 13. Of special note is an approximately 5 cm (2 in.)

Table 13. *Stratigraphic Section of Catskill Formation Rocks from a Temporary Exposure at the Rock Run Church Copper Prospect*

Thickness (cm)	Radioactivity ("mR/hr")	Lithologic description
>70	.02	Grayish-red (5R4/2), fine- to medium-grained, micaceous sandstone.
97	.03	Dark-reddish-brown (10R3/4) shale containing minor reduced zones. Some flaggy, fine-grained sandstone lenses at the top, a few of which approach medium grain size and are reduced.
36	.04	Dark-greenish-gray (5G4/1), micaceous, fine-grained sandstone. Includes sparse calcareous breccia lenses.
21	.08	Olive-gray (5Y3/2), slightly micaceous, highly carbonaceous (plant fragments), fine-grained sandstone to siltstone. Mineralized horizon containing abundant malachite and chrysocolla. Includes assayed interval MHK 748.
>50	.05	Dark-greenish-gray (5G4/1), fine-grained, slightly micaceous sandstone. Mottled with maroon laminae near the base. The color change to grayish red (5R4/2) at the bottom is gradational. More micaceous near the base.

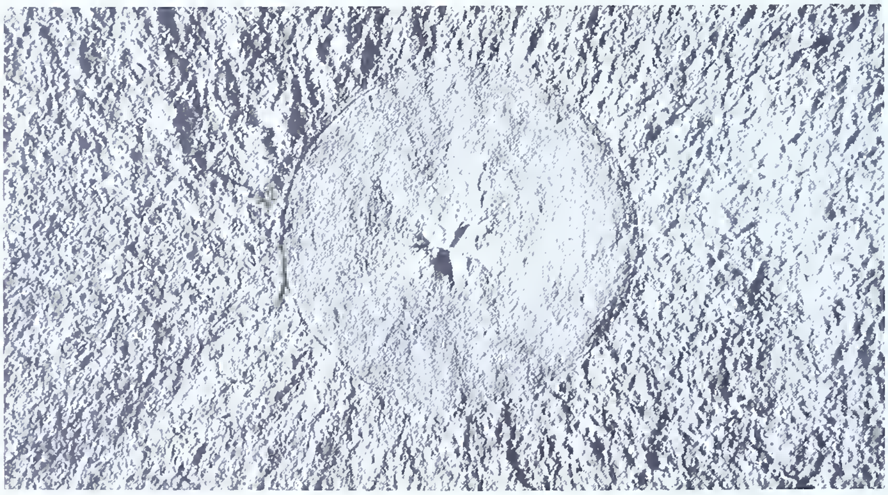

Figure 16. Single fossil-like structure, 0.9 cm (0.35 in.) in diameter, with a central, raised star surrounded by faint concentric banding, Rock Run Church copper prospect. Note the faint radiating pattern in the surrounding matrix.

thick zone located 1.0 m (3.3 ft) above the top of the 0.21-m- (8.3-in.-) thick olive-gray mineralized horizon. This 5-cm- (2-in.-) thick zone of grayish-red (5R4/2), pure shale contains numerous fossil-like unidentified structures such as those shown in Figures 16 to 20 and color photograph 30. Typically, they consist of a nearly circular structure from 0.5 to 1.0 cm (0.2 to 0.4 in.) in diameter, which has very subtle internal concentric zones and relatively pronounced undulating radiations originating from a 5-pointed-star-like center that is 1 mm in diameter. They continue into the third dimension for less than a millimeter. Those sedimentologists questioned disclaimed them as primary inorganic struc-

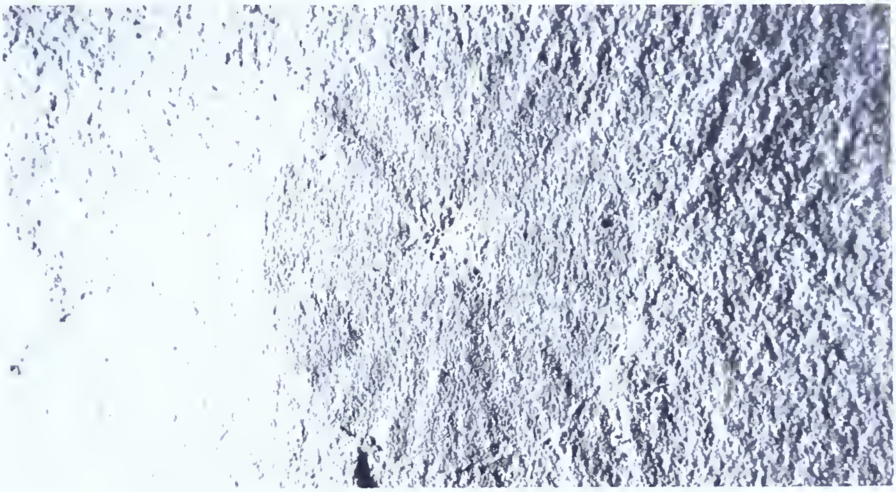

Figure 17. Single fossil-like structure, 1.2 cm (0.47 in.) in diameter, with pronounced radiated internal markings, Rock Run Church copper prospect.

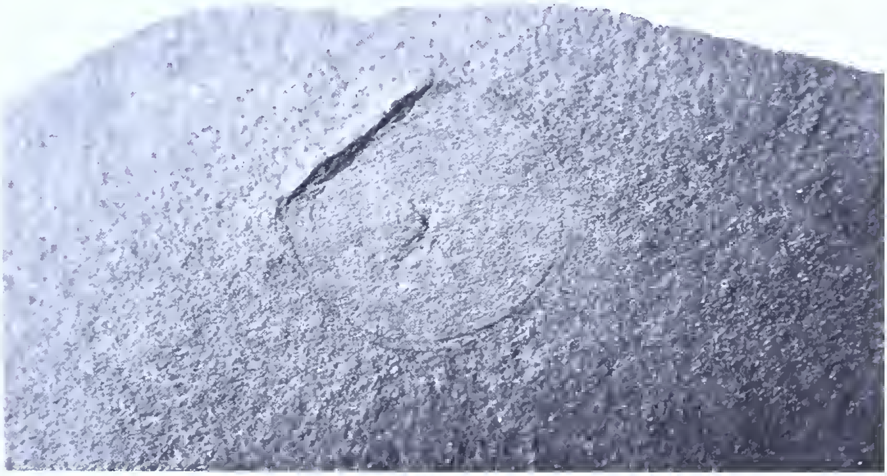

Figure 18. Single fossil-like structure, 0.7 cm (0.3 in.) in diameter, with an apparent planar detachment surface, Rock Run Church copper prospect.

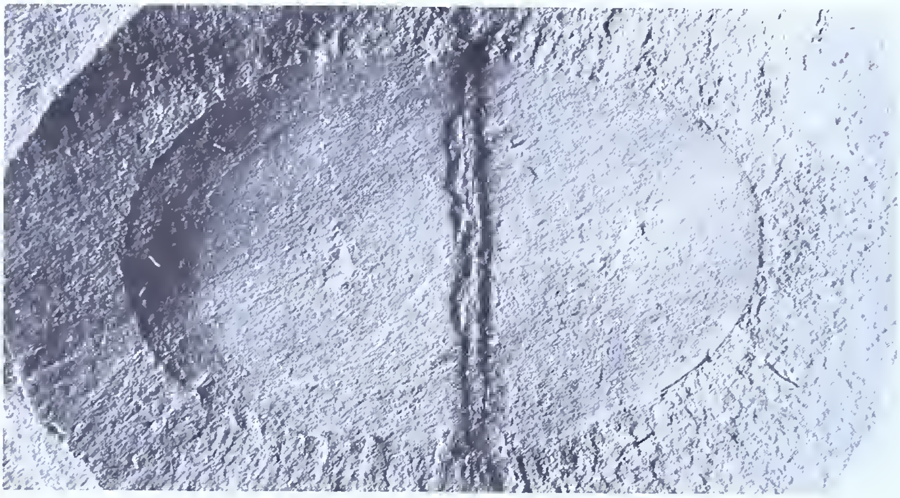

Figure 19. Pair of fossil-like structures attached along a plane, Rock Run Church copper prospect. Doublet is 2.3 cm (0.9 in.) long.

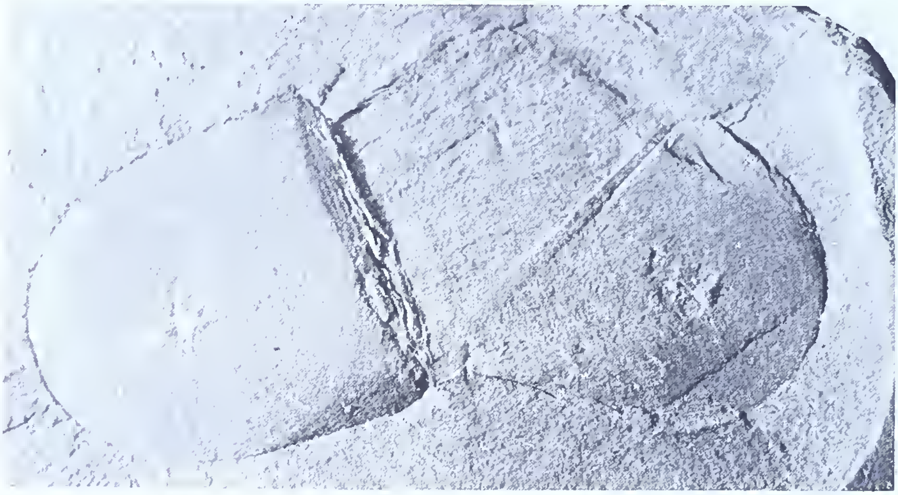

Figure 20. Triplet fossil-like structures with two attachment surfaces on the middle member, Rock Run Church copper prospect. Triplet is 2.5 cm (1 in.) long.

tures. William C. Darrah (personal communication, December 29, 1982) reported that they are possibly gelatinous colonial algae fossils.

Rock Run Uranium Occurrence

1. LOCATION:
   (a) The outcrop is located on the Jack G. Craft property on the northwest side of Rock Run Road, 0.68 km (0.42 mi) northeast of the Sullivan-Lycoming County line and 0.32 km (0.20 mi) northeast of the intersection with Golder Hill Road, Shrewsbury Township, Sullivan

County. The area of both this occurrence and McCauley prospect 28, which is located 29 m (95 ft) to the northeast, is 3.3 km (2.0 mi) northeast of Glen Mawr.

(b) Latitude: 41°20′19″N
Longitude: 76°37′58″W

2. ASSAYS: A 16-cm (6.3-in.) channel sample of gray, micaceous sandstone (Figure 21) contains 248 ppm U_3O_8, 290 ppm copper, 0.38 percent lead, 0.44 troy oz/ton silver, 24 ppm molybdenum, and approximately 157 ppm antimony. In the center of the lens nearly a meter (3 ft) of section is leanly mineralized with uranium, but was not assayed. See sample MHK 745, Appendix 3.

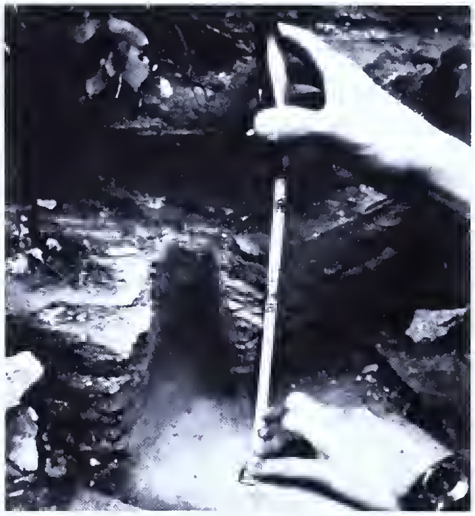

Figure 21. Site of channel sample through 16 cm (6.3 in.) of micaceous sandstone at the Rock Run uranium occurrence. Analyses indicate 248 ppm U_3O_8, 290 ppm copper, 0.38 percent lead, 0.44 troy oz/ton silver, and 24 ppm molybdenum.

3. MINERALOGY:
   (a) Major: None.
   (b) Minor: None.
   (c) Trace: Kasolite as golden-yellow coatings on bedding partings; tiny radiating sprays of cerussite on bedding partings, in some places associated with the kasolite; rare, thin coatings of malachite and anglesite(?) on bedding partings. Pyrite occurs as rare, partial replacements of carbonaceous plant fragments; "limonite" halos occur around fossil plant fragments that have been partially replaced by pyrite.
4. GEOLOGIC DESCRIPTION: This previously unreported occurrence consists of an unprospected series of mineralized outcrops having a total length of 14 m (46 ft) as defined with a Geiger counter or about twice that with a scintillometer, using a 3X background cutoff for the latter. The thickness of reduced rock in the lens is $\geq$ 1.1 m (43 in.). The stratigraphic section is described in Table 14.

   The local maximum radioactivity observed is 2.0 "mR/hr," whereas the average for the 16-cm (6.3-in.) channel sample is 0.35 "mR/hr," and up to 1.0 "mR/hr" is not uncommon.

Table 14. *Stratigraphic Section of Catskill Formation Rocks at the Rock Run Uranium Occurrence*

Exposure is 29 m (95 ft) southwest of the adit at McCauley prospect 28.

Thickness (cm)	Radioactivity ("mR/hr" ±0.02)	Lithologic description
>200	.02–.03	Grayish-red-purple (5RP4/2), fine- to medium-grained, micaceous sandstone.
62	.04–.07	Medium-light-gray (N6), micaceous sandstone. The color change into the overlying oxidized beds appears to be transitional in places. The lower 4 cm is included in the channel sample.
10	.25–.4 up to 2.0	Light-olive-gray (5Y5/2), fine- to medium-grained, flaggy, very micaceous sandstone. Minor kasolite. Contains an abundance of small carbonaceous plant fragments.
60	.05	Light-olive-gray (5Y5/2), medium-grained sandstone. The upper 2 cm is included in the channel sample.
>10	.03	Greenish-gray (5GY6/1) siltstone to fissile, silty shale.

The beds strike N78°E and dip 8°N; joints trend N26°E and dip 90 degrees.

The occurrence is notable because of the absence of calcareous breccia, the extremely micaceous nature of the enriched zone, the near absence of copper mineralization, and the apparent stratigraphic and geochemical (anomalous lead and molybdenum) correlation with the nearby McCauley prospect 28.

FOX RUN VALLEY CLUSTER

Edkin Uranium-Copper Prospect

1. LOCATION:
   (a) The prospect is on the steep west slope of a north-south ridge overlooking Lick Run, 1.11 km (0.69 mi) northwest of the bench mark at 218 m (716 ft) in Glen Mawr, Shrewsbury Township, Lycoming County. The prospect is 0.86 km (0.53 mi) north of Bethel Church and is 57 m (187 ft) lower in elevation than the knob at 348-m (1,143-ft) elevation.
   (b) Latitude: 41°19′10″N
   Longitude: 76°39′52″W
2. ASSAYS: A 25-cm (10-in.) channel sample of gray sandstone containing abundant malachite and carbonaceous plant fragments from 1 m (3 ft) northeast of the short leg of the L-shaped (plan view) adit contains 67 ppm U_3O_8, 1 percent copper, and about 20 ppm silver. See sample MHK 790, Appendix 3.

3. MINERALOGY:
   - (a) Major: Malachite as interstitial micrograins and abundant coatings accompanying or near carbonaceous plant fragments in oxidized and reduced sandstone.
   - (b) Minor: Gypsum as colorless to white micro-botryoids and microcrystal crusts in and near the abundant malachite, and, more rarely, in and near brochantite(?) which has partially oxidized to malachite.
   - (c) Trace: Malachite in rootlet or worm-boring cavities in oxidized siltstone and as radiated acicular microcrystals in ''chalcocite''; ''chalcocite'' replacements of carbonaceous plant fragments; ''apatite'' as phosphatic fish remains; brochantite as crusts of bladelike and stellated acicular microcrystals associated with carbonaceous plant fragments; and rare chrysocolla as green and blue-green crusts associated with carbonaceous plant fragments.

4. GEOLOGIC DESCRIPTION: The prospect consists of a very small, partly caved, L-shaped adit dug into the base of a reduced channel. The long leg of the adit trends approximately N30°E along a joint and is estimated to have been 2 m (7 ft) long. The short leg trends approximately S55°E and is estimated to have been 1.5 m (5 ft) long.

The channel sample was taken and the stratigraphy described (Table 15) at an atypically copper rich zone located 1.0 m (3 ft) northeast of the center axis of the short leg of the adit (Figure 22). This zone, which con-

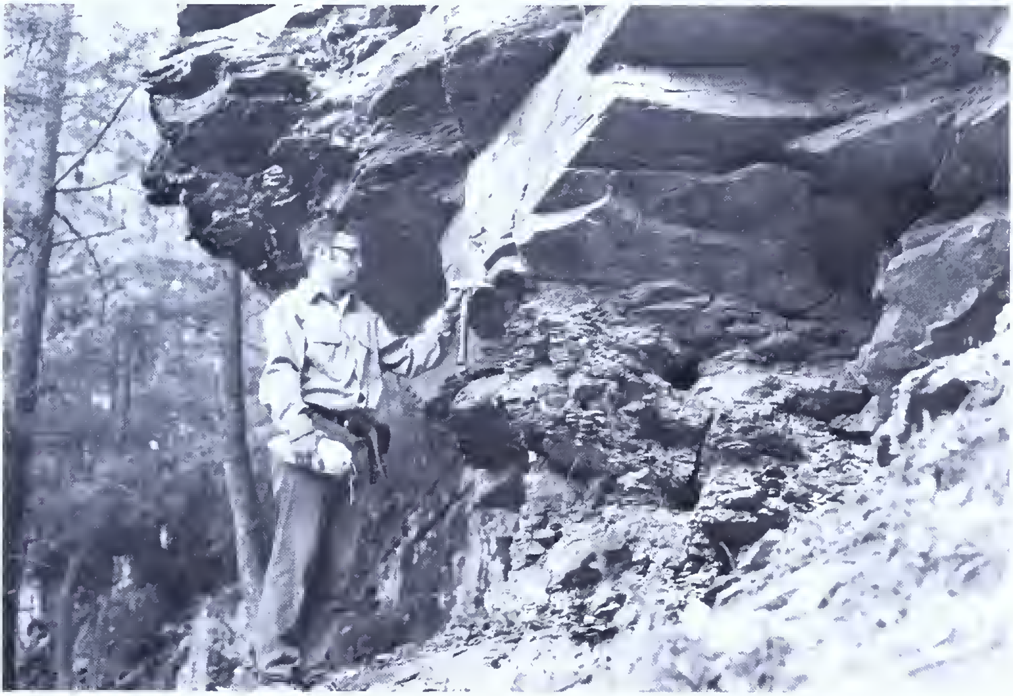

Figure 22. Channel-sample cut and stratigraphic-description site (at hammer), Edkin uranium-copper prospect, also referred to as "The Eagle's Nest" because of the topography. Site of channel sample MHK 790.

Table 15. *Stratigraphic Section of Catskill Formation Rocks at the Edkin Uranium-Copper Prospect*

Exposure is 1.0 m (3 ft) northeast of the center axis of the short leg of the adit.

Thickness (cm)	Radioactivity ("mR/hr")	Lithologic description
>300	.04	Grayish-red (5R4/2), fine-grained, micaceous, laminated to thin- and medium-bedded sandstone. The unit contains reduced laminae near the bottom.
55	.05	Medium-gray (N5), fine-grained, micaceous, thin- to medium-bedded, crossbedded sandstone. Laminae that are between medium gray (N5) and grayish red (5R4/2), carbonaceous plant fragments, and malachite occur near the bottom of the unit. The contact of this unit with the lower unit shows moderate relief.
53	.1	Medium-gray (N5) to dark-greenish-gray (5GY4/1), fine-grained, thin-bedded sandstone containing, in the bottom half, a greenish-gray (5GY4/1), thin siltstone zone, pitted where calcite has weathered. The assayed top 25 cm of this unit (MHK 790) contains abundant carbonaceous plant fragments and malachite, has irregular zones of coloration between medium gray (N5) and grayish red (5R4/2), and exhibits disturbed bedding.
90	.04	Between grayish red (5R4/2) and blackish red (5R2/2). Micaceous, undulating, thin-bedded siltstone and fine-grained sandstone. The top third of the unit contains two calcareous zones approximately 5 cm thick, and a thin zone of grayish-red (5R4/2) shale occurs near the bottom.
>20	.04	Grayish-red (5R4/2) interbedded shale and siltstone laminae.

tains copious malachite and carbonaceous plant fragments, is only 1.4 m (4.6 ft) long and about 15 cm (6 in.) thick near the center. Additional copper-rich material was, however, probably mined from the short leg, based on the dumps. The metastable nature of the outcrop and adits precluded further excavation, and the rapid lithologic changes laterally suggest a limited occurrence. The total length of discontinuous mineralization, which has a radioactivity of $\geq$ 200 cps (measured with the scintillometer), is only 11 m (36 ft). The thickness of the reduced zone on the north side of the short leg of the adit is 1.0 m (3 ft). The zone that has copious malachite and carbonaceous plant fragments yields a maximum radioactivity of 420 cps and a radiometric assay of 80 ppm eU.

A 15-cm- (6-in.-) thick reduced sandstone having an average radioactivity of 0.15 "mR/hr" is exposed near the floor on the east face of the long leg of the adit.

During the uranium boom of the late 1950's, Ernest Edkin discovered "copper flowers" (malachite) at the site of what was probably a much older copper prospect and proceeded to do a small amount of blasting for uranium about 1.5 m (5 ft) northeast of the center axis of the copper adit's short leg. A previously unprospected reduced zone containing slightly radioactive (≤ 200 cps) sandstone was found in a cliff a few hundred meters to the northeast at the same elevation. The occurrence does not, however, seem to be as promising as others in the area.

Fort Sumpter Uranium Prospect

1. LOCATION:
   (a) The prospect is located on property owned by Jim Fought and family near the head of a north-northeast-trending hollow on the west side of the ridge between Big Run and Fox Run, 1.91 km (1.20 mi) north of Tivoli (Dogtown) and 1.86 km (1.16 mi) south-southwest of Mapleton Church, Shrewsbury Township, Lycoming County. The prospect is due south of the top of a 1,160-foot- (353-m-) high knob and is 37.4 ± 3 m (123 ± 10 ft) lower in elevation. The prospect is visible from a vague northeast-trending trail, but even when looking directly northwest from the trail it is not readily distinguished from a natural outcrop.
   (b) Latitude: 41°18′52″N
   Longitude: 76°41′51″W
2. ASSAYS: A 55-cm (21.7-in.) channel sample of gray calcareous sandstone and calcareous breccia contains 55 ppm U_3O_8, 0.34 percent copper, and approximately 20 ppm silver. See sample PRS–1, Appendix 3.
3. MINERALOGY:
   (a) Major: Malachite as crusts, sometimes in microcrystals, on bedding partings in reduced sandstone, and in calcareous breccia, which contains chalcopyrite and carbonaceous plant fragments.
   (b) Minor: None.
   (c) Trace: Chalcopyrite disseminated in calcareous breccia and calcareous sandstone; "chalcocite" as rare micrograins in reduced sandstone; rare galena rimming chalcopyrite grains in carbonaceous matter; "limonite" as micrograins, sometimes showing residual chalcopyrite cores, in calcareous breccia; calcite as secondary, colorless to light-brown crusts, some of which fluoresce tan (UV [ultraviolet], long wave), in calcareous breccia; and "apatite" as rare phosphatic fish remains in calcareous breccia, one containing trace dispersed malachite and another showing chalcopyrite partial replacement, most of which has weathered to "limonite" and malachite.
4. GEOLOGIC DESCRIPTION: The prospected ledge trends approximately N70°E. The site chosen for the stratigraphic description (Table 16) and channel sample is also the reference point because it should be recognizable for several years. The only spot that appears to have been

Table 16. *Stratigraphic Section of Catskill Formation Rocks at the Fort Sumpter Uranium Prospect*

Exposure is at the reference point, approximately 2.25 m (7.4 ft) west of the center of the south-facing open cut.

Thickness (cm)	Radioactivity ("mR/hr")	Lithologic description
>10		Overburden as regolith.
55	.20	Medium-gray (N5) to medium-dark-gray (N4), fine- to medium-grained, micaceous, laminated to thinly crossbedded sandstone with brownish-gray (5YR4/1) laminae near the bottom. The top 20 cm of sandstone is calcareous, and 12 cm of medium-gray (N5) calcareous breccia occurs immediately below. This assayed unit contains abundant malachite on sandstone bedding partings below the calcareous breccia, and carbonaceous plant fragments having malachite in and immediately around them in the calcareous breccia.
>130	.04	Medium-dark-gray (N4) to blackish-red (5R2/2), fine-grained, micaceous, laminated, crossbedded sandstone. The unit is dark greenish gray (5GY4/1) near the top, and is gradationally oxidized to grayish red (5R4/2) near the bottom of the exposure.

excavated is a south-facing open cut that extends from approximately 1 m (3 ft) east of the reference point to 3.5 m (11.5 ft) east. Joints are poorly developed, and the prospect is less well defined than most. Paul Taylor, prime shareholder of the Highland Exploration and Mining Corporation, Inc., reported that two cases of dynamite were used in the circa 1957 excavation. The total estimated thickness of the reduced zone in the open cut is ≥ 1.7 m (5.6 ft).

From the reference point east, mineralization yielding a radioactivity of ≥ 200 cps on the scintillometer can be traced for 14 m (46 ft) at the same elevation. This includes two local enriched areas which yield 600 and 800 cps. From the reference point west, mineralization yielding ≥ 200 cps (through soil) can be detected for 6 m (20 ft). Evidence of additional, discontinuous mineralization can be observed by proceeding 10 m (33 ft) farther west and thence 60 m (197 ft) N60°W. This latter location is the last blast pit in mineralized calcareous breccia to the northwest. It contains trace malachite staining and one of the small, intermediate pits yields 500 cps. The northwest, outlying blast pits in calcareous breccia seem to be slightly higher stratigraphically than the main ledge and open cut. The elevation difference from the top of the channel-sample reference site to the farthest known blast pit to the northwest is $+4 \pm 1$ m (13 ± 3 ft). Both the east and northwest apparent termini of mineralization could be due to lack of outcrop rather than the actual end of mineralization.

Lean mineralization was also observed roughly 150 m (500 ft) to the east at an elevation of about 335 m (1,100 ft). Here, small outcrops of thin-bedded gray sandstone yielded radioactivities of up to approximately 300 cps in underhangs. One moderately large fossil plant fragment with associated "chalcocite," malachite, brochantite, chrysocolla, and microcrystalline quartz was observed.

In view of the moderate number of copper-uranium occurrences at approximately the 335-m (1,100-ft) elevation in this area to the north and northeast of Tivoli (Plate 1), further study of this horizon may be warranted. The Fort Sumpter uranium prospect is the westernmost known copper-uranium occurrence in the Beaver Lake district, but except for car-borne scintillometer reconnaissance and examination of roadside reduced zones, logistical considerations did not permit detailed examination of the area to the west of Big Run.

McCauley Prospect 23

1. LOCATION:
   (a) Despite McCauley's (1961) report to the contrary, the prospect is located on the east side of an unnamed ridge overlooking Muncy Creek, in Shrewsbury Township, Lycoming County, at an elevation of approximately 297 m (975 ft) on the northeast side of the first saddle in the ridge, which is north of Muncy Creek and U.S. Route 220. The elevation of the prospect is 21 m (69 ft) above the top of the pronounced cliff along U.S. 220 and 24 m (79 ft) below the crest of the flat knoll shown at 1,060 ft (323 m) on the topographic map. The prospect is 1.68 km (1.04 mi) northeast of Tivoli (Dogtown) and 0.73 km (0.45 mi) north-northeast of the bench mark at 698 ft (213 m) referred to by McCauley. The prospect is best found by tracing the reduced horizon along the north side of the saddle slightly downslope to the northeast end of the saddle.
   (b) Latitude: 41°18′34″N
   Longitude: 76°40′46″W
2. ASSAYS: A 110-cm (43.3-in.) channel sample of gray, calcareous sandstone contains 83 and 94 ppm[1] U_3O_8 and 3,550 ppm copper. See sample MHK 786, Appendix 3.
3. MINERALOGY:
   (a) Major: Malachite, especially in micaceous sandstone in and near carbonaceous plant fragments and as muscovite-flake pigmentation and coatings on bedding partings.
   (b) Minor: Digenite containing irregular cores of bornite within the larger grains (based on polished sections), disseminated in calcareous breccia.

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[1] Replicate analyses of the same sample.

(c) Trace: Azurite; brochantite(?) in cavities in "chalcocite"; uranophane associated with possible minor beta-uranophane as greenish-yellow coatings on carbonaceous plant fragments[1]; calcite as clear, colorless coatings in and near malachite on bedding partings from a site 6.5 m (21.3 ft) southwest of two hemlocks (approximately 13 m (43 ft) southwest of the entrance to the open cut); covellite disseminated in the calcareous breccia; zeunerite-metazeunerite or torbernite-metatorbernite as pale-yellow-green, thin, tabular microcrystals in cavities in "chalcocite," which has partially replaced a carbonaceous plant fragment; calcite or aragonite as white, fibrous veinlets, altered to malachite pseudomorphs in part, which have partially replaced a carbonaceous plant fragment; and chrysocolla(?) accompanied by malachite as a partial oxidation of brochantite microcrystals associated with a carbonaceous plant fragment.

4. GEOLOGIC DESCRIPTION: McCauley prospect 23 was discovered by Paul Taylor and Wilbur Mills. Taylor (of the Highland Exploration and Mining Company, Inc.) formerly leased and prospected the site. The resulting open cut is 2.7 m (8.9 ft) long in a direction of approximately N60°W, averages about 2 m (6 ft) wide, and is 2.3 m (7.5 ft) deep at the rear (Figure 23). The stratigraphy was described (Table 17) and the channel samples were taken near the northwest end of the northeast side of the open cut.

An outcrop of fine-grained sandstone beneath the roots of two hemlock trees 6.5 m (21.3 ft) S40°W of the entrance to the open cut yields a

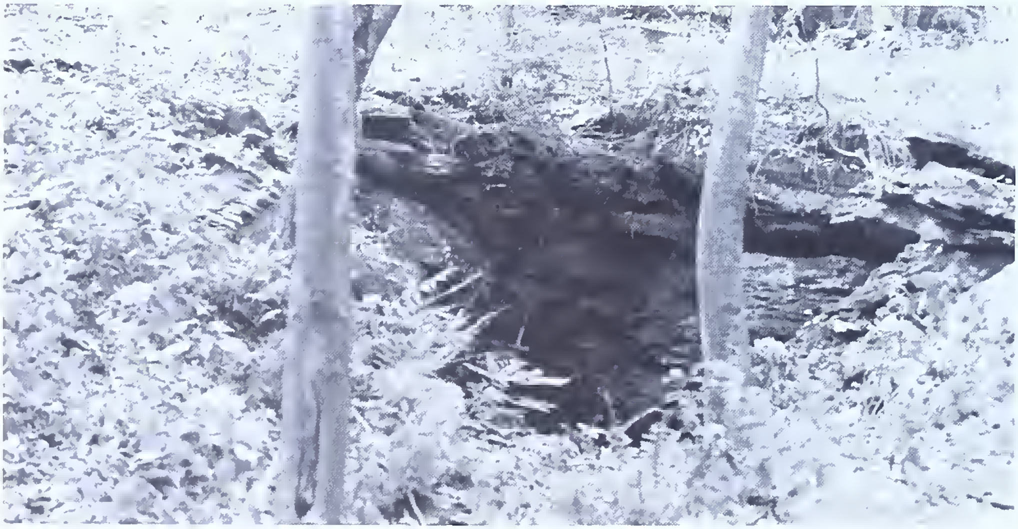

Figure 23. Open cut, looking northwest, at McCauley prospect 23, developed by the Highland Exploration and Mining Company, Inc. The channel samples and stratigraphic descriptions were taken near the back of the right face.

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[1] Possibly a mixture consisting of trace uranophane and a major amount of the amorphous, pistachio-green "BB" mineral found throughout the district.

Table 17. *Stratigraphic Section of Catskill Formation Rocks at McCauley Prospect 23*

Exposure is near the northwest end of the northeast side of the open cut.

Thickness (cm)	Radioactivity ("mR/hr")	Lithologic description
220	.3	Medium-gray (N5) to grayish-red (5R4/2), fine- to medium-grained, micaceous, calcareous sandstone which is laminated to thin bedded and contains carbonaceous, malachite-bearing plant fragments and some malachite in the rock immediately surrounding the fragments. The unit is predominantly oxidized in the top half and reduced in the bottom half, and color mottling occurs throughout. The unit contains a varying amount of calcite, especially in lenses of gray to red calcareous breccia near the bottom. A continuous, approximately 5 cm thick, punky, shaly zone rich in carbonaceous material and containing malachite and minor azurite occurs approximately 40 cm above the floor of the open cut. A similar, but discontinuous, very carbonaceous zone containing minor calcareous breccia occurs approximately 85 cm above the floor of the open cut. The assayed 110-cm-thick, gray, calcareous sandstone sample (MHK 786) is from the bottom half of this unit's exposure in the open cut, defined by using a 0.3-"mR/hr" cutoff at the top. More realistically, this is probably a 0.1-"mR/hr" cutoff due to mass effect. The average radioactivity of the assayed zone is 0.5 "mR/hr," and the maximum is 0.7 "mR/hr"; both readings are probably high due to the geometry.

radiometric assay of 200 ppm eU. A small excavation, located 6.5 m (21.3 ft) farther west of the two hemlock trees on a bearing of S60°W, exposes gray sandstone that has malachite on bedding surfaces and yields readings up to 1,000 cps on the scintillometer.

Approximately 145 m (475 ft) S70°W of the open cut at McCauley prospect 23, there is a prospected overhang containing minor malachite. This area yields readings up to 600 cps and appears to be a continuation of the same reduced zone exposed at McCauley prospect 23.

Because of the erroneous location provided by McCauley and the limited scope of the present study, further examination is recommended. This is also based on the presence of over 2 m (7 ft) of mineralized, reduced rock at a horizon (305 m, or 1,000 ft in elevation) containing several known occurrences in the area (Plate 1). The difficulty with which Wilbur Mills, who had lived in the area and who discovered the occurrence, relocated the prospect was matched by the authors upon their return. Mr. Mills' field assistance is gratefully acknowledged, but it should be noted that because of relocation difficulties and unfavorable weather the occurrence has not been as thoroughly examined as most in the district. The 145-m (475-ft) S70°W site in the saddle proper, for example, was examined in a minimal amount of daylight and may be underrated.

McCauley Prospect 24

1. LOCATION:
   (a) The prospect is located on the Joseph McGrath property on the southwest side of Highland Lake Road 2.42 km (1.50 mi) north of Tivoli and 1.35 km (0.84 mi) south-southeast of Mapleton Church, Shrewsbury Township, Lycoming County. The elevation is estimated to be 283 m (930 ft) and the adit entrance is 5.5 m (18 ft) west of the center of the road, here trending approximately N23°W.
   (b) Latitude: 41°19′11″N
   Longitude: 76°41′24″W
2. ASSAYS: A 72-cm (28.3-in.) channel sample of gray sandstone containing carbonaceous plant fragments and malachite has 17 ppm U_3O_8, 9,500 ppm (0.95 percent) copper, and 3,200 ppm lead. A 42-cm (16.5-in.) channel sample of calcareous breccia from below the sandstone contains 8 ppm U_3O_8, 4,750 ppm copper, and 650 ppm lead. See samples MHK 744 and 743, Appendix 3.
3. MINERALOGY:
   (a) Major: Malachite as crusts, some micro-botryoidal, in and near carbonaceous plant fragments and on bedding partings in sandstone; also in sulfide-bearing calcareous breccia.
   (b) Minor: None.
   (c) Trace: "Manganese dendrites" on bedding and various fracture surfaces in sandstone and calcareous breccia; azurite on sandstone bedding partings and sandstone-calcareous breccia contacts; chrysocolla associated with carbonaceous plant fragments in sandstone; "apatite" as phosphatic fish remains in calcareous breccia.

   In addition, in polished section the "chalcocite" in calcareous breccia typically consists of bornite with successive rims of digenite and djurleite. Rare, separate grains consist of idaite with minute chalcopyrite exsolution lamellae and substantial replacement rims of covellite.
4. GEOLOGIC DESCRIPTION: The workings consist of a 12.1-m- (38.7-ft-) long adit (Figure 24) driven in about 1880 for copper, and a V-shaped, horizontal undercut from which about 3 tons of rock was removed during the uranium exploration of the late 1950's. The adit trends due west for the outer 9 m (30 ft) and slightly northwest toward the back. Near the entrance, this adit is 1.5 m (5 ft) wide and 0.75 m (2.5 ft) high. In the vicinity of the adit, the reduced lens, which appears to have two parts, is 1.8 m (5.9 ft) thick and can be traced along the outcrop for a total length of 21.7 m (71 ft). The undercut, located 3.5 m (11.5 ft) south of the adit's center, exposes carbonaceous plant fragments and associated malachite in sandstone on the south side near the bottom and

Figure 24. View looking out of McCauley prospect 24, dug for copper during the period 1880–82 by William Coleman Hall and two other miners.

malachite on sandstone bedding partings in the roof. The lens is concealed at both ends, but is thin near the limits of exposure.

Sevon and others (1978, p. 80) note that the exposed sequence constitutes a fining-upward fluvial cycle not more than 200 m (650 ft) above the top of the marine-nonmarine transition zone. The amount of scour at the base of the cycle is small. The basal calcareous breccia represents a channel-lag deposit and the overlying sandstones are point-bar deposits. The sandstone beds near the base are massive, whereas those near the top are flaggy.

A stratigraphic description of the cycle exposed at the south side of the adit entrance is presented in Table 18. The maximum grain size observed is in the 50-cm- (20-in.-) thick unit of medium-grained, gray sandstone. About 6 m (20 ft) from the entrance, the adit roof and upper 45 cm (18 in.) consist of medium-grained, gray sandstone underlain successively by 3 cm (1 in.) of gray calcareous breccia, 6 cm (2.4 in.) of gray shale, and 45 cm (18 in.) of reddish shale-mudstone to red siltstone. In the rear of the adit, the roof exposes gray mudstone containing trace malachite on a slightly scoured contact with the reddish shale-mudstone of the walls. Thus, neither the mineralization observed at the entrance nor the appropriate host rocks continue very far in this direction.

The calcareous breccia and lower 46 cm (18 in.) of sandstone were channel sampled 1 m (3 ft) south of the adit center, whereas the upper 26 cm (10 in.) of the sandstone was channel sampled at the south side of the adit entrance. The sandstone sample consisted of 50 cm (20 in.) of cross-bedded, medium-grained gray sandstone beginning immediately above the calcareous breccia, 20 cm (8 in.) of overlying carbonaceous sandstone, and 2 cm (0.8 in.) of the overlying micaceous gray sandstone. Where sampled, the calcareous breccia has an average radioactivity of 0.03 "mR/hr." The sandstone average is about 0.1 "mR/hr" based on 0.08 for the lower 50 cm (20 in.) and 0.14 for the upper 20 cm (8 in.), ignoring the uppermost 2 cm (0.8 in.) of micaceous sandstone.

Sevon and others (1978) estimated the strike of bedding at N54°E and the dip at 2°NW, and reported a vertical joint set trending about N23°E.

Because the better mineralization has a maximum radioactivity of 0.15 "mR/hr" (with extremely local areas of 0.3), and because the mineral-

Table 18. *Stratigraphic Section of Catskill Formation Rocks at McCauley Prospect 24*

Exposure is on the south side of the adit, 2.45 km (1.52 mi) north of Tivoli.

Thickness (cm)	Radioactivity ("mR/hr" ± 0.02)	Lithologic description
>85	.02-.03	Grayish-red (5R4/2), fine-grained, slightly micaceous sandstone. Mostly planar bedded; 1- to 2-cm bed thickness.
55	.02-.03	Pale-brown (5YR5/2), fine- to medium-grained, micaceous sandstone. Includes a few small calcareous breccia lenses up to 8 cm thick.
25	.02-.05	Medium-light-gray (N6), fine- to medium-grained, micaceous sandstone. Moderate amount of malachite on bedding. Base was included in MHK 744.
20	.05-.10	Medium-light-gray (N6), fine- and medium-grained, slightly micaceous sandstone containing very abundant carbonaceous plant fragments and trace malachite stains. Includes azurite in the adit. Included in MHK 744.
50	.04	Medium-gray (N5), medium-grained sandstone containing abundant malachite and carbonaceous plant fragments up to 3 by 12 cm, especially near the base. Contains trace "chalcocite"(?), azurite, and chrysocolla (some of the latter occurs in plant-fossil shrinkage cracks). Included in MHK 744.
40	.05	Medium-gray (N5), micaceous calcareous breccia containing gray shale chips and sparse red chips near the base. Contains malachite and sparse phosphatic fish remains. Assay sample MHK 743.
>5	.02-.03	Grayish-red (10R4/2) siltstone containing fine-grained mica flakes.

ization is of limited extent along the outcrop and within the adit, the occurrence appears to be only of academic interest.

The owner reported an exploration drill hole about 15 m (50 ft) north of the barn. The fresh chip pile contained about four reddish siltstone chips to every gray silty shale chip, and had a radioactivity of 0.03 "mR/hr."

Mahar (1978, p. 22) noted that he found mineralization at a site indicated by an "X" on his Figure 2 and Plate 1. J. H. Way (personal communication, 1979) reported finding a single sample of calcareous breccia containing malachite at this site (Plate 1, present study).

McCauley Prospect 24–1/2 of Mahar (Birch Still Road Reduced Zone)

1. LOCATION:
   (a) The occurrence is located on the northeast edge of Birch Still Road 1.93 km (1.20 mi) northwest of Glen Mawr and 0.92 km (0.57 mi)

southwest of the confluence of Lake Run and Lick Run, Shrewsbury Township, Lycoming County.
(b) Latitude: 41°19′16″N
Longitude: 76°40′28″W

2. ASSAYS: An 18-cm (7.1-in.) channel sample of medium-grained, gray sandstone and minor calcareous breccia from the base of the reduced zone contains 3 ppm U_3O_8 and 440 ppm copper. See sample MHK 752, Appendix 3.
3. MINERALOGY:
   (a) Major: None.
   (b) Minor: Malachite as coatings and radiated fibrous microcrystals on bedding partings in sandstone.
   (c) Trace: Azurite and chrysocolla coatings on bedding partings in sandstone.
4. GEOLOGIC DESCRIPTION: The occurrence consists of lean copper mineralization at the base of a 2.2-m- (7.2-ft-) thick reduced zone exposed in a roadside ditch. Ernest Edkin of Glen Mawr reported that this occurrence was briefly prospected for uranium during the period 1955-60. The reported small prospect trench, now removed by road improvement, was apparently a failure, as revealed by the very low uranium assay and the Geiger counter reading of 0.03 "mR/hr" for the richest interval.

   Mahar (1978, p. 22) correlates this horizon with the one at McCauley prospect 24, located 1.3 km (0.81 mi) to the west, but does not appear to have verified the relation or considered regional bedding attitudes. Bedding at the Birch Still Road reduced zone trends about N37°W and dips 10°NE.

Table 19. ***Stratigraphic Section of Catskill Formation Rocks at McCauley Prospect 24-1/2 of Mahar***

Exposure is in a roadside ditch approximately 2 km (1.2 mi) northwest of Glen Mawr.

Thickness (cm)	Radioactivity ("mR/hr")	Lithologic description
>50	.02	Grayish-red (5R4/2) to blackish-red (5R2/2), thin-bedded, fine-grained sandstone.
194	.02	Dark greenish gray (between 5GY4/1 and 5G4/1) to between medium gray (N5) and medium dark gray (N4). Medium-grained, micaceous sandstone containing grayish-brown (5YR3/2) laminae near the bottom.
9	.02	Medium-gray (N5) to medium-dark-gray (N4) calcareous sandstone containing dark-greenish-gray (5GY4/1) shale chips near the top.
16	.03	Medium-gray (N5) to medium-dark-gray (N4), medium-grained, micaceous sandstone. Malachite was observed at the top along strike where carbonaceous plant fragments are present.
1	.03	Dark-greenish-gray (5GY4/1) shale.
>50	.03	Grayish-red (5R4/2) shale.

A minor set of slickensides near the base of the reduced zone trends about N8°W, plunges 24°S, and possesses vague chattermarks, the classical interpretation of which suggests that the hanging wall has moved down. Because the supergene malachite was observed 7 cm (3 in.) above the slickensides, copper may have been locally remobilized at the time of slickenside formation.

A stratigraphic description of the occurrence is presented in Table 19.

Old Copper Open Pit

1. LOCATION:
   (a) This small prospect is located on the west side of a ridge facing Fox Run at a point 2.0 km (1.2 mi) northeast of Tivoli and 2.50 km (1.55 mi) west-northwest of Glen Mawr, Shrewsbury Township, Lycoming County. The pit rim is located S76°W of a knob that has an elevation of 1,140 ft (347 m), and is 18 ± 3 m (59 ± 10 ft) lower than the knob in elevation. It is best recognized by finding the cluster of birch trees at the northeast end of a vegetation scar (Figure 25). The pit is probably on Mrs. Sperry's farm.
   (b) Latitude: 41°18′54″N
   Longitude: 76°41′01″W

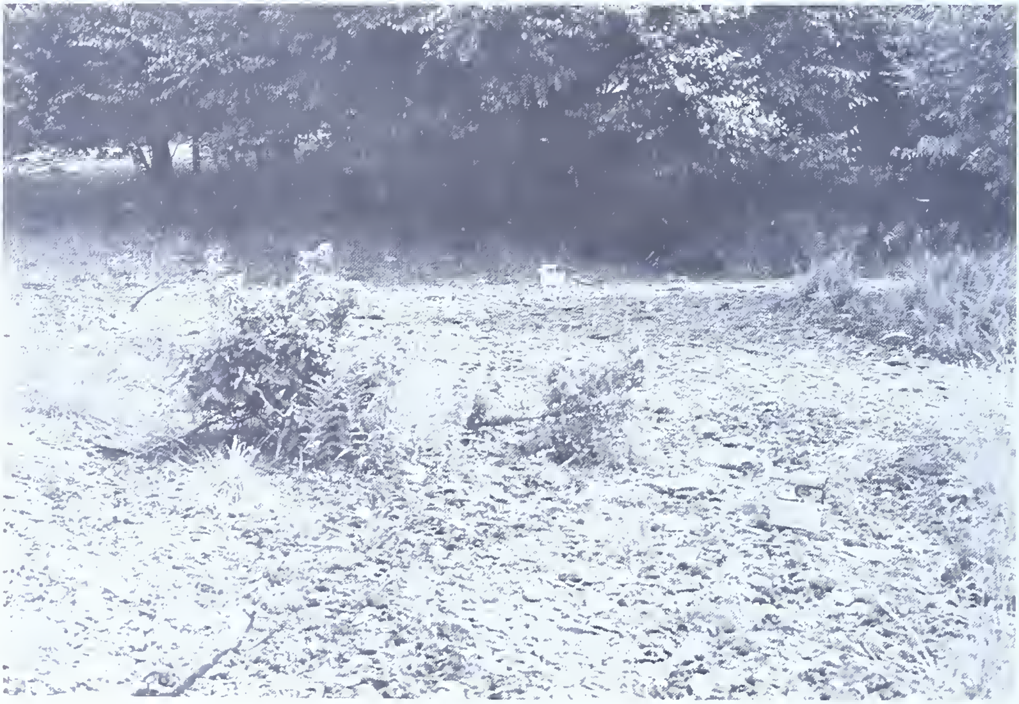

Figure 25. Vegetation anomaly, 25 m (80 ft) long, Old Copper open pit. The long axis of the vegetation anomaly is marked by the scintillometer and Geiger counter.

2. ASSAYS: A composite of all types of reduced rock from the open-pit dumps and vegetation scar contains 6 ppm U_3O_8, 700 ppm copper, and 1,000 ppm lead. See sample MHK 783, Appendix 3.
3. MINERALOGY:
   (a) Major: "Limonite" in weathered carbonaceous plant fragments.
   (b) Minor: Pyrite in gray calcareous sandstone containing carbonaceous plant fragments.
   (c) Trace: Galena in rock described above; malachite in laminated to thin-bedded, crossbedded gray sandstone; and "apatite" as phosphatic fish remains in gray sandstone rich in shale chips.
4. GEOLOGIC DESCRIPTION: The open pit is 6.5 m (21 ft) long and 4.5 m (15 ft) wide, is now approximately 1 m (3 ft) deep, and trends N50°E. The northeast end appears to have been substantially deeper originally. The maximum radioactivity observed on the dump of the open pit is approximately 200 cps using the scintillometer.

   Beginning 24.5 m (80 ft) S35°W of the open-pit center, the cluster of birch trees opens into a meadow scarred by a strong vegetation anomaly. The vegetation anomaly is 24.5 m (80 ft) long in a N25°E direction and 4 to 11 m (13 to 36 ft) wide, and heads down-drainage from the open pit. Vegetation in the meadow outside the scar is hardly lush,[1] but within the scar only a few scattered plants were observed on a grassless slope. Several stunted black birch (*Betula lenta*), flowering dogwood (*Cornus florida*), and hawthorn (*Crataegus* sp.) grow on the scar, but the hawthorn leaves are curled and yellow relative to those in the adjacent meadow (Figure 26). Rare nonwoody plants noted (July 1979 and August 1981) were wild carrot (*Daucus carota*), gray (old field) goldenrod (*Solidago nemoralis*), early goldenrod (*Solidago juncea*), blackberry(?) (*Rubus* sp.), common St. Johnswart (*Hypericum perforatum*), dwarf cinquefoil (*Potentilla canadensis*), common mullein (*Verbascum thapsus*), common milkweed (*Asclepias syriaca*), and horse-nettle (*Solanum carolinense*), the horse-nettle being the most abundant. A few hayscented (boulder) ferns (*Dennstaedtia punctilobula*) exist where shaded by the stunted woody plants. The nonwoody plants are characteristic, in part, of waste places and old fields. The semiquantitative trace-element analyses (Appendix 3) of a composite of all types of reduced rock from the dump and scar do not indicate high amounts of any vegetation inhibitors. Low pH induced by decomposition of *in situ* pyrite associated with abundant carbonaceous plant fragments cannot be ruled out as a cause for the botanical anomaly.

   Because of backfilling in the open pit, mineralized rock is not exposed in outcrop. The host rock of the limonite-stained carbonaceous plant fragments is a fine- to medium-grained, gray sandstone. The occurrence is of interest only with respect to the botanical anomaly.

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[1] Wilbur Mills, who previously farmed this area, reported that the plow was in the air more than it was in the ground.

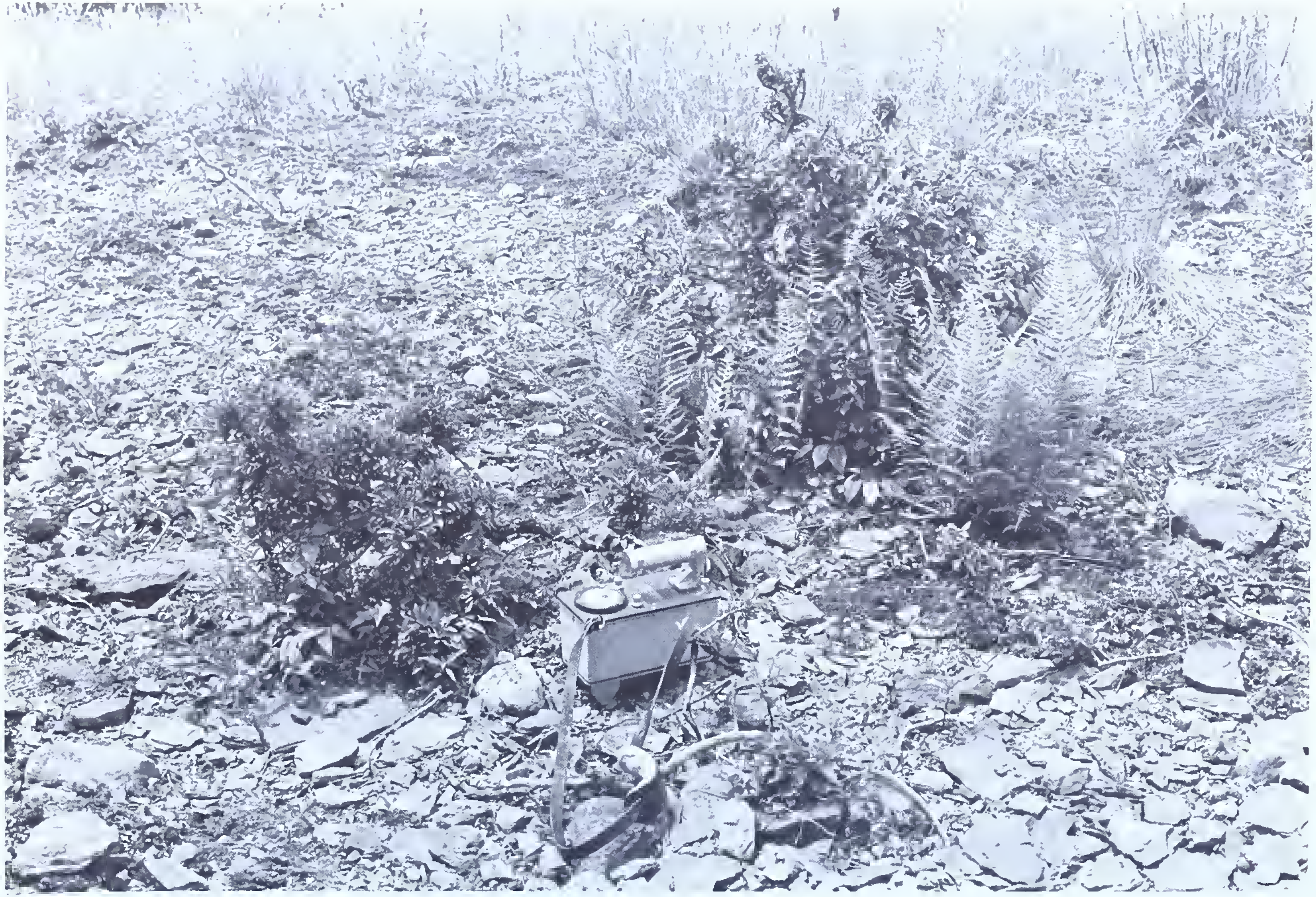

Figure 26. Stunted birch and hawthorn, the latter having curled and yellowed leaves, with fern at the vegetation anomaly, Old Copper open pit area.

Old Farm Uranium-Copper Occurrence

1. LOCATION:
   - (a) The occurrence is located on the James Montgomery property in the northeast part of the first saddle in a north-south-trending ridge between Fox Run and Big Run, 1.18 km (0.73 mi) north of Tivoli (Dogtown), Shrewsbury Township, Lycoming County (Plate 1). The occurrence is approximately 85 m (280 ft) N30°E of the apparent center of the saddle and 6 ± 1 m (20 ± 3 ft) higher in elevation. The site is on a hillside that faces southeast, 1.15 km (0.71 mi) northwest of the bench mark at 698 feet (213 m) on the northwest side of U.S. Route 220.
   - (b) Latitude: 41°18′32″N
     Longitude: 76°41′34″W
2. ASSAYS: A 123-cm (48-in.) channel sample of gray sandstone contains 143 ppm U_3O_8, 3,400 ppm copper, and 1,600 ppm lead. A radiometric assay yielded 150 ppm eU about 0.5 m (1.6 ft) below the mineralized overhang. See sample MHK 787, Appendix 3.
3. MINERALOGY:
   - (a) Major: None.
   - (b) Minor: Uranophane as pale-yellow coatings,[1] nonfluorescent and fluorescent pale green (UV, short wave and long wave), on bedding partings; and malachite as coatings, sometimes micro-botryoidal, on bedding partings and associated with carbonaceous plant fragments at the main and east sites.
   - (c) Trace: From the main site—chrysocolla as green to bluish-green crusts, sometimes micro-botryoidal, associated with carbonaceous plant fragments and on bedding partings; chrysocolla-malachite mixture as green to bluish-green micro-botryoids on bedding partings; gypsum as colorless microcrystals, usually in groups, on bedding partings; anglesite as light-gray, resinous crusts associated with the gypsum; and metatorbernite as a pale-green coating on a fossil twig cast having a radioactivity of 7 "mR/hr." From the 35-m (115-ft) east site—barite as clear, colorless, tabular crystals associated with uranophane and malachite; and an unidentified substance as black masses with vitreous luster and conchoidal fracture. From the 45-m (148-ft) east site—opal (variety hyalite) as thin, colorless, fluorescent bright-green (UV, short wave and long wave) coatings. "Chalcocite" occurs at the main and east sites as fine disseminations in sandstone.
4. GEOLOGIC DESCRIPTION: The occurrence consists of a 57-m- (187-ft-) long, discontinuous series of uraniferous outcrops discovered by Wilbur Mills during the uranium boom of the late 1950's (Figure 27). In deference to the owner, James Montgomery, the occurrence has never been prospected. Near the west end, where it is best exposed, the total thickness of the reduced zone is ≥ 1.8 m (5.9 ft). This outcrop is only 7 m (23 ft) in length, but the radioactive zone can be traced approximately

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[1] May have faded after exposure.

Figure 27. Unprospected uraniferous outcrops near the western end of the Old Farm uranium-copper occurrence.

7 m (23 ft) to the west of the reference point, where it is lost beneath a N40°E-trending trail. To the east, the radioactive zone can be traced N75°E at approximately the same horizon for a distance of 50 m (165 ft).

The stratigraphy at the channel-sample site, 2 m (6.6 ft) east of the western end of the main outcrop (reference point), is described in Table 20. The base of the reduced zone is exposed here, but the top has been removed by erosion. This outcrop contained a fossil twig cast which was 1 cm (0.4 in.) wide and 29 cm (11.4 in.) long, and had a maximum radioactivity of 7 "mR/hr"; metatorbernite was noted on the twig cast. Elsewhere, this outcrop contained a trace of an orangish oxidation color similar to that of the chalcopyrite-bearing sandstone lens at the Middle Catskill Reduced Zone uranium-copper occurrence.

A local radioactive area at 31.5 m (103 ft) east yields 1,000 cps on the scintillometer, and a slab of calcareous breccia float yields 200 to 300 cps. Another spot at 35 m (115 ft) yields 3,000 cps or 0.6 "mR/hr," and one at 40 m (131 ft) yields 2,000 cps. A 3/4- by 1/4- by 1/4-m (30- by 10- by 10-in.) piece of "maroon" sandstone float at 45 m (148 ft) yielded 3,500 cps and 1,800 ppm eU. At 50 m (164 ft) there is "maroon" sandstone a few centimeters thick, which contains carbonaceous plant fragments and yields 1,500 cps. Malachite and disseminated "chalcocite" were found at the 35-m (115-ft), 45-m (148-ft), and 50-m (164-ft) sites, and uranophane was found at the first two sites.

Table 20. *Stratigraphic Section of Catskill Formation Rocks at the Old Farm Uranium-Copper Occurrence*

Exposure is 2 m (6.6 ft) east of the west end of the main 7-m- (23-ft-) long outcrop (reference point).

Thickness (cm)	Radioactivity ("mR/hr")	Lithologic description
≥ 155	.25	Medium-gray (N5), fine- to medium-grained, micaceous sandstone in laminated to thin-bedded, undulating beds; laminae are medium gray (N5) to moderate brown (5YR3/4), especially near the top. The unit contains a calcareous zone, a 7-"mR/hr" fossil twig cast bearing metatorbernite, and malachite and chrysocolla on bedding partings. Sparse carbonaceous plant fragments are present. A 123-cm-thick, 0.3-"mR/hr" (average) assay sample was collected from this unit using a 0.1-"mR/hr" cutoff.
36	.07	Medium-gray (N5) to grayish-red (5R4/2), laminated shale and siltstone, predominantly reduced in the top half to oxidized in the bottom half. The unit exhibits disturbed bedding and contains small lenses of reduced calcareous breccia near the top.
30	.07	Between grayish red (5R4/2) and blackish red (5R2/2). Micaceous, thin-bedded siltstone.

Relative to most occurrences in this district, the grade, thickness, and lateral extent of this occurrence are good. This and the fact that the occurrence was never prospected suggest that further study in search of less spotty mineralization may be warranted.

Tivoli Overlook Copper-Uranium Occurrences 1 and 2 and the Rusty Logjam Open Cut

1. LOCATION:

(a) The Tivoli Overlook copper-uranium occurrences are located on the steep, south-southwest end of a north-south-trending spur 1.0 km (0.62 mi) northeast of Tivoli (Figure 28). Occurrence 1 is at an elevation of about 302 m (990 ft), or about 10 m (33 ft) below the bench, 0.95 km (0.59 mi) northeast of the U.S. Route 220 bridge over Big Run in Tivoli, and 0.28 km (0.17 mi) northwest of the iron bridge over Muncy Creek, Shrewsbury Township, Lycoming County. This occurrence was located by R. B. Koeberle during an internship with the Pennsylvania Geological Survey. At the time he was seeking the badly mislocated McCauley prospect 23. Occurrence 2, to the north, is located 1.0 km (0.62 mi) northeast of the U.S. Route 220 bridge over Big Run and 0.34 km (0.21 mi) northwest of the iron bridge over Muncy Creek.

The essentially barren Rusty Logjam open cut is located 0.83 km (0.52 mi) northeast of the bridge over Big Run and 0.24 km (0.15 mi)

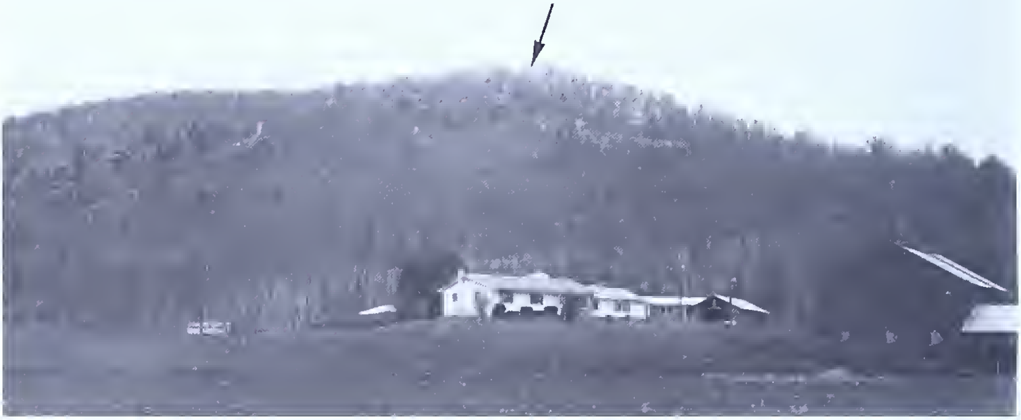

Figure 28. View of Tivoli Overlook copper-uranium occurrences 1 and 2 (below arrow), looking northeast from Tivoli. Partial snow cover accentuates the natural outcrops.

west of the bridge over Muncy Creek. The top of the dump is 8.5 m (28 ft) below the level of a pronounced flat.

	Occurrence 1	Occurrence 2	Rusty Logjam open cut
(b) Latitude:	41°18′11″N	41°18′14″N	41°18′07″N
Longitude:	76°41′02″W	76°41′03″W	76°41′03″W

2. ASSAYS: A 48-cm (19-in.) channel sample of gray sandstone from occurrence 1 contains 8 ppm U_3O_8 and 2,350 ppm copper. A 15-cm (6-in.) channel sample of gray, carbonaceous shale-siltstone from occurrence 2 contains 396 ppm U_3O_8, 3.1 percent copper, 1,050 ppm arsenic, and 210 ppm lead. See samples MHK 750 and 751, Appendix 3.
3. MINERALOGY:

Tivoli Overlook copper-uranium occurrence 1

(a) Major: Malachite as coatings and micro-botryoids on bedding partings.
(b) Minor: Azurite as radiated microcrystals and coatings on bedding partings.
(c) Trace: None.

Site 21 m (69 ft) N23° W of occurrence 1

(a) Major: Malachite; "chalcocite" as log replacement and disseminated micrograins in sandstone.
(b) Minor: Chrysocolla.
(c) Trace: Chalcophyllite as bluish, micaceous, six-sided microcrystals; barite as clear microplates; drusy quartz; brochantite; metatorbernite(?); and azurite as microcrystals on siltstone.

Tivoli Overlook copper-uranium occurrence 2

(a) Major: Malachite as coatings and micro-botryoids.
(b) Minor: Djurleite(?)-covellite(?) as partial replacements of carbonaceous plant fragments. Chrysocolla as green to blue (some banded) crusts and microbotryoids.
(c) Trace: "Apatite" as phosphatic fish remains; brochantite as crystalline crusts and microcrystals; and rare langite and/or posnjakite as platy crusts and radiated, acicular microcrystals.

4. GEOLOGIC DESCRIPTION: The Tivoli Overlook area contains a number of small copper-uranium occurrences at approximately the same stratigraphic horizon. From south to north, the occurrences in this natural cliff are designated Tivoli Overlook copper-uranium occurrence 1, log at 16.7 m (55 ft) north of occurrence 1, log at 21 m (69 ft) north of occurrence 1, lens at 11.1 m (36 ft) S20°E of occurrence 2, and Tivoli Overlook copper-uranium occurrence 2. In addition, there is the barren Rusty Logjam open cut estimated to be approximately 45 to 55 m (150 to 175 ft) lower in elevation.

Tivoli Overlook copper-uranium occurrence 1 consists of a limited exposure of about one-half meter (1.6 ft) of reduced rock containing copper. The beds strike N83°W and dip 18°N, and vertical joints trend N28°E. The reduced zone disappears to the north, whereas there is a minor amount of barren calcareous breccia to the south. The stratigraphy is described in Table 21.

The log at 16.7 m (55 ft) north of occurrence 1 occurs in a 35-cm- (14-in.-) thick reduced zone of fine-grained sandstone that has an average radioactivity of 0.4 "mR/hr." The maximum radioactivity on the log is 0.85 "mR/hr."

The log at 21 m (69 ft) north of occurrence 1 occurs in a 38-cm- (15-in.-) thick reduced zone. The log was 10 cm (4 in.) wide and more than 22 cm (8.7 in.) long, and the long axis was oriented approximately

Table 21. ***Stratigraphic Section of Catskill Formation Rocks at Tivoli Overlook Copper-Uranium Occurrence 1***

Exposure is 1.0 km (0.62 mi) northeast of Tivoli.

Thickness (cm)	Radioactivity ("mR/hr")	Lithologic description
>100	.03	Pale-red (5R6/2) to grayish-red (5R4/2), fine-grained, planar-bedded sandstone.
48	.05 .39 max.	Medium-light-gray (N6) to medium-dark-gray (N4), fine-grained, laminated to medium-bedded sandstone. The laminae are very micaceous, and abundant malachite and minor azurite occur on bedding partings. This assayed unit is brownish gray (5YR4/1) at the base and contains dark-greenish-gray (5G4/1) shale chips near the top.
>50	.02	Grayish-red (10R4/2) shale with interbedded siltstone and trace malachite on bedding surfaces.

N45 °W. The maximum radioactivity of the log was 1.2 ''mR/hr'' before and 1.0 ''mR/hr'' after partial excavation.

The lens at 11.1 m (36 ft) south of occurrence 2 occurs in a 40-cm- (16-in.-) thick reduced horizon. Using a cutoff of 2 ''mR/hr,'' the radioactive lens is 4 cm (1.6 in.) thick and 40 cm (16 in.) long. It consists of gray to brownish-gray shale to fine-grained sandstone containing abundant carbonaceous plant fragments. Major minerals include ''chalcocite'' as partial replacements of carbonaceous plant fragments and as disseminated micrograins in sandstone, and malachite; minor minerals include chrysocolla, barite as colorless to yellow-brown dipyramidal microcrystals, and a carbonate and sulfate-bearing green unidentified mineral; and trace minerals include quartz microcrystals.

Tivoli Overlook copper-uranium occurrence 2 is located in a 63-cm- (25-in.-) thick reduced zone of which the lowest 15 cm (6 in.) is mineralized and has an average radioactivity of 0.3 ''mR/hr.'' Using a cutoff of 0.05 ''mR/hr,'' the mineralized zone is only 2.2 m (7.2 ft) long. Vertical joints trend N29 °E. The stratigraphy is described in Table 22.

The Rusty Logjam open cut consists of a small, S50 °E-trending open cut that has a vertical face at the northwest end. Rock on the dump southeast of the trench consists of reduced, fine-grained sandstone containing abundant, large carbonaceous plant fragments. Similar rock can

Table 22. *Stratigraphic Section of Catskill Formation Rocks at Tivoli Overlook Copper-Uranium Occurrence 2*

Exposure is near the center of a 2.2-m- (7.2-ft-) long, mineralized lens, 1.0 km (0.62 mi) northeast of Tivoli.

Thickness (cm)	Radioactivity (''mR/hr'')	Lithologic description
150	.03	Brownish-gray (5YR4/1) to grayish-red (10R4/2), fine-grained, thin-bedded sandstone; trace of crossbedding.
50	.03	Medium-light-gray (N6) to dark-greenish-gray (5GY4/1), medium-grained, medium-bedded sandstone. Unit is slightly micaceous, has abundant shale chips on several horizons, and contains carbonaceous plant fragments and associated malachite near the bottom. The lowest 2 cm was included in the 15-cm-thick assayed sample.
13	.35 .80 max.	Dark-greenish-gray (5GY4/1) to medium-dark-gray (N4), crossbedded shale, siltstone, and fine-grained sandstone containing small lenses of calcareous breccia. Malachite and chrysocolla are abundant from copper sulfide replacements of carbonaceous plant fragments. The top 1 cm of this assayed unit is extremely rich in carbonaceous material and copper mineralization; 3 cm of weathered calcareous breccia occurs immediately below.
>100	.035	Grayish-red (5R4/2) interbedded shale and slightly micaceous, fine-grained sandstone.

be traced southeast below the flat for over 30 m (100 ft). The only anomalous radioactivity observed, 0.06 "mR/hr," occurs in a gray siltstone about 3 m (10 ft) above the floor at the northwest end of the trench. Neither copper nor uranium mineralization was observed, but the copious iron staining on the sandstone suggests that uranium could have been lost during weathering of the pyrite. The original purpose of the prospecting done via this open trench is unknown. It closely resembles Creekside Rod and Gun Club prospects 1 and 2.

STRAWBRIDGE CLUSTER

Strawbridge Copper Prospect 1

1. LOCATION:
   - (a) The prospect is located on the McClain estate on the southeast side of a northeast-trending hollow on the southern side of the first ridge south of Muncy Creek, Penn Township, Lycoming County. The adit opens to the northwest at a point 0.63 km (0.39 mi) southeast of bench mark 747, 0.82 km (0.51 mi) west-southwest of bench mark 780, and 0.4 km (0.25 mi) northwest of the outlet of Strawbridge Lake. The roof of the adit entrance is approximately 23 m (75 ft) lower in elevation than the flat shown on the topographic map at 1,080 ft (329 m). The adit entrance is S30°E of the Strawbridge Northwest uranium-copper lens, which is much less thoroughly concealed in hemlock forest timber slash.
   - (b) Latitude: 41°18′44″N
     Longitude: 76°37′31″W
2. ASSAYS: A 33-cm (13-in.) channel sample of the upper sandstone contains 384 ppm U_3O_8, 18,500 ppm copper, 1.43 troy oz/ton silver, 530 ppm arsenic, and 1,600 ppm lead. A 21-cm (8.3-in.) channel sample of calcareous breccia and sandstone from between the other assayed sandstone units contains 34 ppm U_3O_8, 8,000 ppm copper, and 2,300 ppm lead. A 125-cm (49-in.) channel sample of the lower sandstone, siltstone, and calcareous breccia units contains 30 ppm U_3O_8 and 1,250 ppm copper. See samples MHK 755–757, Appendix 3.
3. MINERALOGY:
   Adit
   - (a) Major: Malachite on micaceous sandstone bedding partings, in and near vitrain logs (Figure 29), and as coatings in calcareous breccia.
   - (b) Minor: Chrysocolla as shrinkage-crack fillings in carbonaceous logs, and azurite on sandstone bedding partings and as micrograins in calcareous breccia.
   - (c) Trace: Linarite-like mineral as blue coatings associated with malachite on micaceous bedding partings near the large log; golden-yellow barite associated with chrysocolla and drusy quartz in shrinkage cracks in carbonaceous limbs; "apatite" as phosphatic fish remains in calcareous breccia; and an unidentified

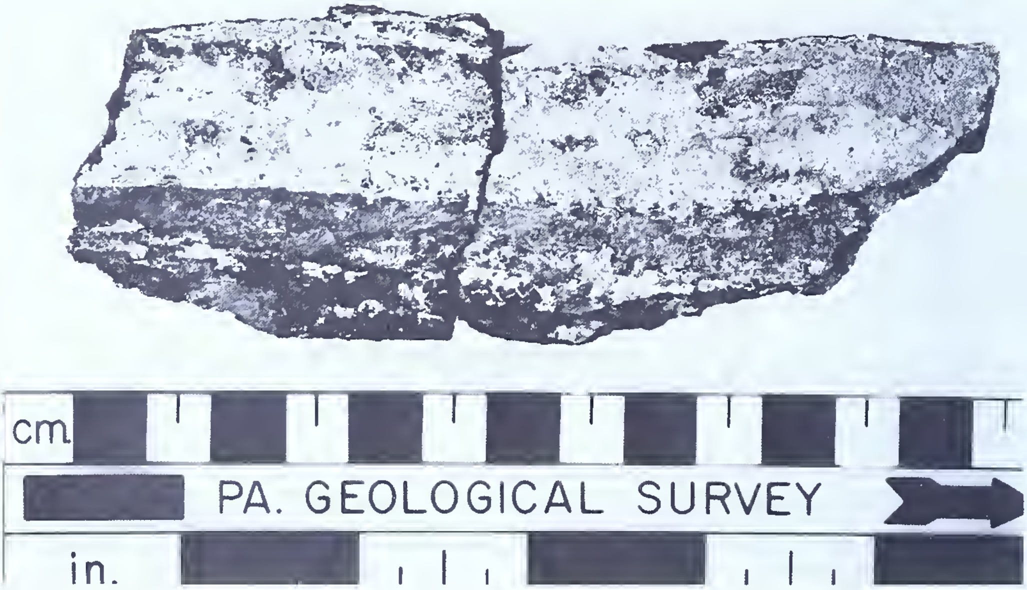

Figure 29. Carbonaceous log fragment containing abundant malachite, from the widened entrance to Strawbridge copper prospect 1.

mineral as fluorescent green (UV, short wave), colorless to white coatings, some of which are micro-botryoidal, in calcareous breccia.

Site at 14 m (46 ft) N20°E of reference point

(a) Major: None.
(b) Minor: None.
(c) Trace: Barite as pearly white, micaceous crystals; malachite as coatings and disseminations; brochantite as thin, emerald-green coatings; zeunerite as apple-green waxy masses in plant-fragment replacements; an unidentified bright-yellow secondary uranium mineral associated with zeunerite; chlorite as grayish slickenside fillings; and chrysocolla as green to bluish-green coatings.

4. GEOLOGIC DESCRIPTION: Strawbridge copper prospect 1 consists of an adit, a connected, vertical air shaft, a mineralized outcrop just to the southwest, and an isolated northeast site (Plates 1 and 2).

As measured from the reference point (center of roof at adit entrance) the adit has an overall trend of approximately S55°E for 25.5 m (84 ft). As shown in Figure 30, the area around the entrance was widened in an apparently successful pursuit of copper mineralization. The adit assumes its regular shape 3.60 m (11.8 ft) southeast of the reference point, at station I, where it is 1.57 m (5.2 ft) high and 1.30 m (4.3 ft) wide. From station I to station II there is a distance of 2.85 m (9.3 ft) on a bearing of S58°E, and the adit at station II is 1.36 m (4.5 ft) high and 1.34 m (4.4 ft) wide. Beyond station II, the roof is higher and of oxidized rock. From station II to station III there is a distance of 16.9 m (55.4 ft) on a bearing

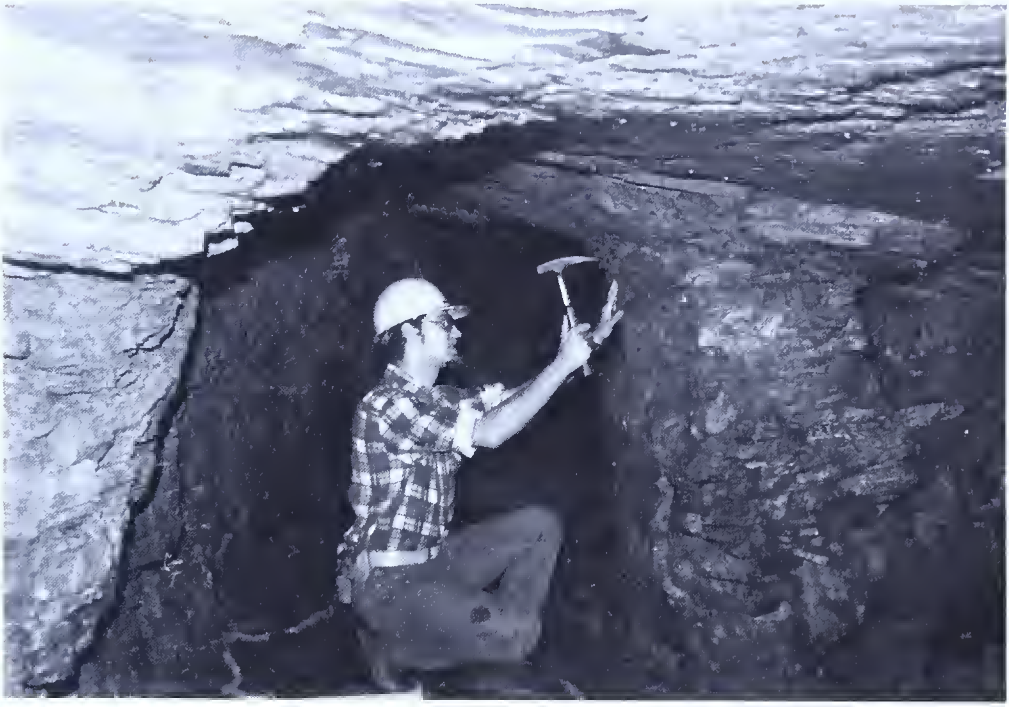

Figure 30. R. B. Koeberle in the adit of Strawbridge copper prospect 1, near Station I about 3.6 m (12 ft) southeast of the reference point. Here the width decreased as mining progressed beyond the mineralized portion of the reduced zone.

of S47°E. At station III, the adit is 1.37 m (4.5 ft) high and 1.71 m (5.6 ft) wide. From station III to station IV (the southwest edge of the air shaft) there is a distance of 2.20 m (7.2 ft) on a bearing of S80°E. A schematic cross section through the adit is shown on Plate 3. The median strike of bedding between stations III and IV is N70°W, and the median dip is 6°N. As shown on Plate 2, joints trend N31 ± 2°E and are subvertical.

In the widened entrance to the adit, copper mineralization is moderately abundant, but the lateral variation is extreme (see Plate 3). In the southeast part of the widened entrance at the channel-sample and stratigraphic-description site there is about 1.8 m (5.9 ft) of reduced rock that has copper-uranium mineralization. The stratigraphy at this site is described in detail in Table 23. Copper mineralization in the adit extends only 0.5 m (1.6 ft) southeast of the joint at station II and even there is limited to about 1 cm (0.4 in.) containing trace malachite and azurite. The stratigraphy at station II is summarized in Table 24.

The northwest edge of the air shaft to the adit is located 25.3 m (83 ft) S55°E of the reference point and 7.15 m (23.5 ft) higher in elevation. (This is 12.4 m (41 ft) N52°E of the prospect 2 shaft and 0.9 m (3 ft) higher in elevation.) The air shaft is 1.8 by 1.4 m (5.9 by 4.6 ft) in cross section at the top and 5.3 m (17.4 ft) deep (Figure 31). It should be ap-

Table 23. *Stratigraphic Section of Catskill Formation Rocks at Strawbridge Copper Prospect 1, Channel-Sample Site*

Exposure is 4 m (13 ft) south of the reference point, 0.4 km (0.25 mi) northwest of the outlet of Strawbridge Lake.

Thickness (cm)	Radioactivity ("mR/hr")	Lithologic description
>33	.21	Olive-gray (5Y4/1) to medium-dark-gray (N4), fine-grained sandstone containing abundant malachite and minor azurite. Sparse, large carbonaceous plant fragments containing malachite along shrinkage cracks. Major amounts of malachite also occur in the sandstone host within a few centimeters of such carbonaceous plant fragments. Corresponds to upper assayed unit.
~10	.08	Medium-dark-gray (N4) calcareous breccia.
~ 9	.12	Dark-greenish-gray (5GY4/1), fine-grained sandstone. Together with the above approximately 10 cm, this unit corresponds to the middle assayed sample.
39	.13	Olive-gray (5Y4/1) to medium-dark-gray (N4) siltstone.
60	.08	Medium-gray (N5) to olive-gray (5Y4/1), fine-grained sandstone. Trace malachite. Slightly calcareous near the base.
25	.08	Light-brownish-gray (5YR6/1) to medium-gray (N5) calcareous breccia. Contains dark-greenish-gray (5G4/1) shale chips. Together with the above 39- and 60-cm units, this unit corresponds to the lower assayed sample.
>5	.07	Olive-gray (5Y4/1) to dark-gray (N3), medium-grained, micaceous sandstone containing grayish-red (10R4/2) and dark-greenish-gray (5G4/1) shale chips.

Table 24. *Stratigraphic Section of Catskill Formation Rocks at Strawbridge Copper Prospect 1, Station II*

Exposure is 0.4 km (0.25 mi) northwest of the outlet of Strawbridge Lake (see Plate 2).

Thickness (cm)	Radioactivity ("mR/hr")	Lithologic description
60	.06	Oxidized and reduced, fine-grained sandstone.
3	.04	Reduced calcareous breccia. Pinches out 0.8 m to the northwest.
90	.06	Gray, fine-grained sandstone with a minor amount of red laminae which are on the order of 1 cm thick.

No copper mineralization was observed to the southeast of Station 11, suggesting that the mineralized rock on the dump at Strawbridge copper prospect 2 comes from a separate lens.

proached with caution; between visits by the authors, a fleet white-tailed deer became trapped in the shaft and died.

The dump to the adit extends 7.8 m (25.6 ft) N74°W from the reference point to the far end of its top. From the far end of the top of the

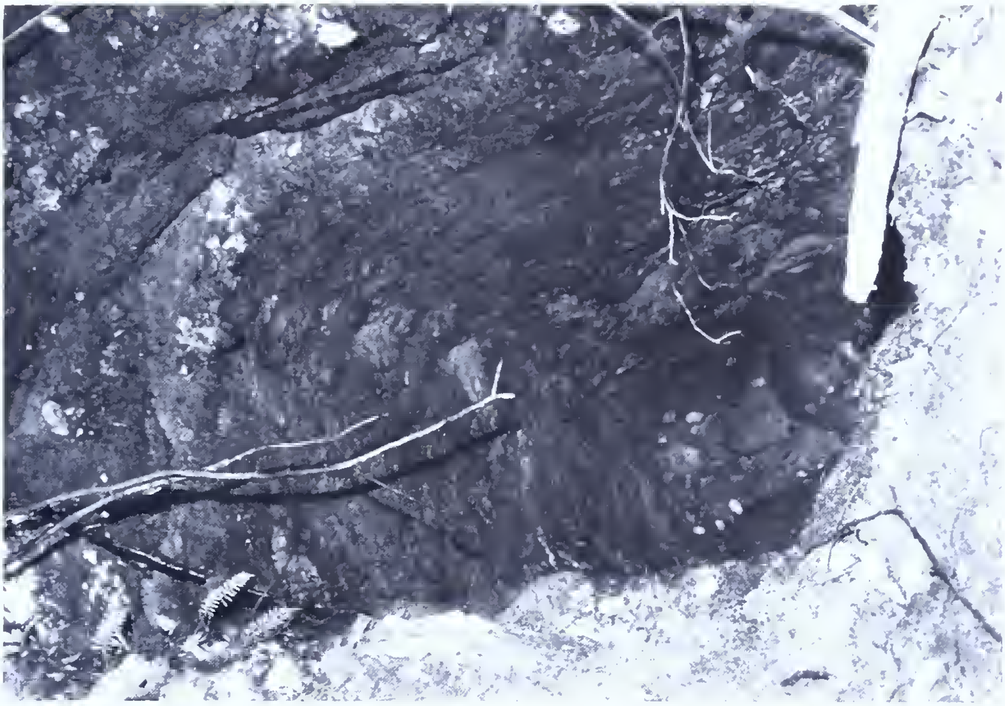

Figure 31. View down the open air shaft to Strawbridge copper prospect 1.

dump northwest to its toe is 8.5 m (27.9 ft) on an incline of 29 degrees. The dump appears rather barren, probably because it is veneered with the last rock to be excavated, i.e., that from the southeast part of the adit. Such a practice suggests that a public stock offering was not involved. (This is based on observations that dumps to publicly offered zinc-lead prospects in Pennsylvania were veneered with the richest samples on the surface or spread out in a thin layer over a larger area.)

The leanly mineralized outcrop (Plate 2) begins 4.15 m (13.6 ft) southwest of the reference point and continues for 24.7 m (81 ft). This outcrop exposes a series of calcareous breccia and gray sandstone lenses along a large joint face. The face is shown schematically in Plate 3. The rock is barely enriched in copper or uranium, but sedimentologic study may be warranted because of the extensive exposure and partial three-dimensional data provided by the adit.

The site at 14 m (46 ft) N20°E of the reference point is a localized area containing abundant muscovite, carbonaceous material, and minor zeunerite, which yields a maximum radioactivity of 6.6 ‘‘mR/hr.’’

Strawbridge Copper Prospect 2

1. LOCATION:

(a) The prospect is located on the McClain estate on a bench on the southeast side of a northeast-trending hollow on the south side of the first ridge south of Muncy Creek. The site is 0.63 km (0.39 mi) southeast of bench mark 747, 0.82 km (0.51 mi) west-southwest of bench mark 780, and 0.4 km (0.25 mi) northwest of the outlet of Strawbridge Lake, Penn Township, Lycoming County. The vertical shaft collar is 23.7 m (77.7 ft) S26°E of the reference point in this area (i.e., the center of the roof at the entrance to the adit of Strawbridge copper prospect 1) and 6.25 m (20.5 ft) higher in elevation. With respect to the flat at the top of the hill (at elevation 1,080 feet, or 330 m) the shaft collar is 16.1 ± 1 m (52.8 ± 3 ft) lower in elevation. The apparent dump to this shaft is located 10 m (33 ft) S74°E of the collar (Plate 2).

(b) Latitude: 41°18′44″N
Longitude: 76°37′30″W

2. ASSAYS: Because *in situ* mineralization was inaccessible, a composite dump sample consisting of 3.5 kg (7.7 lb) of 2- to 3-cm (1-in.) chips of gray sandstone was collected and found to contain 78 ppm U_3O_8, 2,450 ppm copper, and 1,100 ppm lead. See sample MHK 753, Appendix 3.
3. MINERALOGY:
   (a) Major: None.
   (b) Minor: Chalcopyrite and "chalcocite" as disseminations in gray sandstone and partial replacements of carbonaceous plant fragments.
   (c) Trace: Gypsum (variety selenite) as clear, colorless microcrystals (color photograph 10); malachite; "apatite" as phosphatic fish remains; galena as local, very rich disseminations around plant fossils; anglesite(?) as grayish-white coatings on weathered galena; linarite(?) as coatings associated with brochantite(?) and with cerussite as light-gray microcrystals; and chrysocolla on carbonaceous plant fragments. Polished sections reveal disseminated bornite grains with covellite-rimmed chalcopyrite lamellae, as well as separate grains of bornite and chalcopyrite and an unknown that has an overall orange-bronze color and a myriad of very fine grained, irregular exsolution lamellae that yield dark-red-brown to blue-gray polarization colors.
4. GEOLOGIC DESCRIPTION: Strawbridge copper prospect 2 consists of a vertical shaft at least 3.4 m (11.2 ft) deep which is approximately rectangular in cross section and has a corresponding dump. The dump is 6.5 by 6.5 m (21 by 21 ft) across and 1 m (3 ft) high. In cross section, the shape of the dump could be approximated by an arc of a circle. The dump proper has an average radioactivity of 0.1 "mR/hr" on contact, and individual hand specimens have radioactivities ranging from 0.03 to 0.11 "mR/hr" and an average of 0.08 "mR/hr." The radioactivity of the dump is 420 cps as determined with the scintillometer held 0.7 m (28 in.) above the apex of the dump.

   The dump consists predominantly of gray, thin-bedded, fine-grained micaceous sandstone containing sparse carbonaceous plant fragments and moderately abundant gray shale chips. The reduced rock is distinctly different from any observed *in situ* in the Strawbridge area. Because the southeast end of the adit at prospect 1 contains only oxidized rock and the shaft at prospect 2 may be about 2 m (7 ft) too shallow to reach the minor "ore" horizon, the rock on the prospect 2 dump is probably from an isolated, but related, lens.

Strawbridge Uranium-Copper Lens and Intermediate Point

1. LOCATION:

(a) The Strawbridge uranium-copper lens is located on the McClain estate on the south side of the first ridge south of Muncy Creek at a point 0.72 km (0.45 mi) southeast of bench mark 798, 0.81 km (0.50 mi) southwest of bench mark 780, 0.33 km (0.20 mi) west-northwest of the outlet of Strawbridge Lake, and 17 ± 1 m (56 ± 3 ft) lower in elevation than the 1,080-foot (330-m) flat on the ridge. The bearing from the lens to a notch in the next ridge to the south is S28°E, on an incline 6.5 degrees from the horizontal.

The intermediate point is located 56 m (184 ft) N47°W of the Strawbridge uranium-copper lens and 26 m (85 ft) S13°W of the southeast end of the calcareous-breccia-bearing joint face in which the adit of Strawbridge copper prospect 1 is located. Both occurrences are in Penn Township, Lycoming County.

	Strawbridge uranium-copper lens	Intermediate point
(b) Latitude:	41°18′40″N	41°18′43″N
Longitude:	76°37′29″W	76°37′31″W

2. ASSAYS: A 50-cm (20-in.) channel sample of gray calcareous breccia and siltstone from the uranium-copper lens contains 34 ppm U_3O_8 and 7,000 ppm copper. See sample MHK 754, Appendix 3.

3. MINERALOGY:

Strawbridge uranium-copper lens

(a) Major: None.
(b) Minor: Malachite.
(c) Trace: None.

Intermediate point

(a) Major: None.
(b) Minor: Malachite, especially on bedding partings near carbonaceous plant fragments in micaceous sandstone.
(c) Trace: Salmon and white barite on joint; pale-yellow barite in sandstone; "chalcocite" replacements of carbonaceous plant fragments; and quartz cross fiber.

4. GEOLOGIC DESCRIPTION: The Strawbridge uranium-copper lens consists of an approximately 2 m (6 ft) long, unprospected outcrop. The closest outcrop along strike is located a few meters to the northwest, where the calcareous breccia is more oxidized and barren. The median strike of bedding in the area of the Strawbridge uranium-copper lens is N55°W, and the median dip is 1°NE, but the variation in the strike is

large. Joints trend N30°E and dip 87°SE. The stratigraphic section at the lens is described in Table 25. The total thickness of reduced rock is 71 cm (28 in.), of which 50 cm (20 in.) is mineralized.

Table 25. *Stratigraphic Section of Catskill Formation Rocks at the Strawbridge Uranium-Copper Lens*

Exposure is at the channel-sample site, 0.33 km (0.20 mi) west-northwest of the outlet of Strawbridge Lake.

Thickness (cm)	Radioactivity ("mR/hr")	Lithologic description
>65	.03	Pale-red (5R6/2), thin-bedded, fine- to medium-grained sandstone.
8	.05	Medium-light-gray (N6), fine-grained sandstone containing abundant mica on bedding partings.
50	.12	Medium-gray (N5) calcareous breccia and siltstone containing similarly colored, small, scattered, fine-grained sandstone lenses. Scattered gray shale chips, malachite, and carbonaceous plant fragments are also present. Assayed unit (MHK 754).
13	.03	Medium-gray (N5), fine-grained sandstone.
>70	.02	Grayish-red (5R4/2), fine-grained sandstone.

The intermediate point consists of an excellent outcrop at the base of a reduced channel (Plate 1), but it contains only scattered uranium-copper mineralization. As noted, this outcrop is located between the adit of Strawbridge copper prospect 1 to the northwest and the Strawbridge uranium-copper lens, described above, to the southeast. The stratigraphy at the intermediate point may be generalized as follows: more than 1.0 m (3 ft) of oxidized, medium-grained sandstone at the top; 1.8 m (5.9 ft) of gray, medium-grained sandstone; 1.0 m (3.3 ft) of reduced calcareous breccia containing large sandstone lenses and erosional channels up to 0.2 m (8 in.) deep cut into the underlying unit (18 carbonaceous plant fragments having malachite in or near them were observed, typically at the top contact of this unit); and more than 0.8 m (2.6 ft) of oxidized, fine-grained sandstone at the base. The average radioactivity of the 1.0-m (3.3-ft) calcareous breccia is estimated to be 0.07 "mR/hr." The richest plant fragment collected has a radioactivity of 1 "mR/hr," but the largest copper-stained carbonaceous plant fragment in the outcrop yields 1.5 "mR/hr." Salmon and white barite occur on a vertical fracture that is curved but trends approximately N40°E. This barite is about 10 cm (4 in.) below the horizon of mineralized plant fragments.

Neither the Strawbridge uranium-copper lens nor the intermediate point is of any economic value except to illustrate the presence of isolated mineralized lenses at a favorable horizon.

Strawbridge Northwest Uranium-Copper Lens

1. LOCATION:
   (a) The "overhang-adit" at the Strawbridge uranium-copper lens is at an elevation of approximately 295 m (970 ft), similar to the elevation of the adit at Strawbridge copper prospect 1, but is located N30°W of that adit across a northeast-trending hollow. The "overhang-adit" is 0.47 km (0.29 mi) northwest of the outlet of Strawbridge Lake, 0.57 km (0.35 mi) southeast of bench mark 798, and 0.83 km (0.52 mi) west-southwest of bench mark 780, in Penn Township, Lycoming County, 2.38 km (1.48 mi) east of Glen Mawr. The lens is probably on the McClain estate.
   (b) Latitude: 41°18′45″N
   Longitude: 76°37′32″W
2. ASSAYS: A 55-cm (22-in.) channel sample of gray sandstone contains 50 ppm U_3O_8, 435 ppm copper, and 2,000 ppm lead. See sample MHK 784, Appendix 3.
3. MINERALOGY:
   (a) Major: None.
   (b) Minor: "Limonite" in weathered fossil-plant replacements.
   (c) Trace: Malachite and rare azurite rimming limonitic traces of plant fragments; rare pyrite replacements of plant fragments containing trace "chalcocite"; rare bornite, "chalcocite," and chalcopyrite replacements of carbonaceous plant fragments; unidentified pistachio-green mineral associated with limonite after chalcopyrite; and barite(?) in limonitic traces of plant fragments. Trace calcite as white to tan, chalky, microglobular crusts occurs with malachite in the outcrop of gray sandstone just above the channel samples.
4. GEOLOGIC DESCRIPTION: The occurrence consists of a 22-m- (72-ft-) long exposure of leanly mineralized gray sandstone in which there is an "overhang-adit" (Figure 32). This overhang could be the result of an early aborted attempt to drive an adit, but no definite tool marks were observed. The area below the overhang is 2.3 m (7.5 ft) deep, 2.1 m (6.9 ft) wide, and approximately 1.2 m (3.9 ft) high. To the eye, bedding appears to be horizontal, but it cannot be properly measured. The occurrence of the adit at Strawbridge copper prospect 1 in a similar reduced zone or continuation of the same reduced zone at the same elevation across the hollow suggests a very low dip in this area. Distinct vertical joints near the overhang trend N28°E; one is coated with drusy quartz crystals.

   The channel samples were collected from the east side of the overhang. A vertical groove chipped in the sandstone ledge here was used as the reference point for the radiometric measurements listed in Table 26 and is also the site of the stratigraphic description in Table 27. Compared to most occurrences in the district, the radiometric readings taken along strike are rather uniform and the reduced zone is approximately

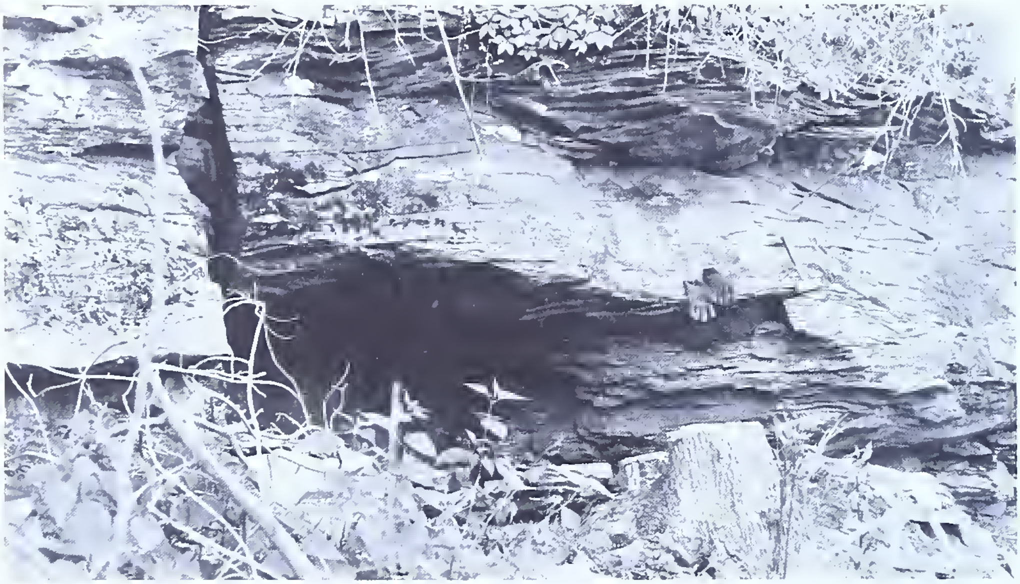

Figure 32. "Overhang-adit" at Strawbridge Northwest uranium-copper lens. The cut for channel sample MHK 784 and the stratigraphic-description site are slightly to the left of the recently sawed stump. The oxidized sandstone near the joint may be anomalously radioactive.

Table 26. *Radiometric Measurements along the Strawbridge Northwest Uranium-Copper Lens*

Located 2.4 km (1.5 mi) east of Glen Mawr, Penn Township, Lycoming County.

Location (relative to channel-sample site)		Counts per second[1]	eU (ppm)[2]	Comments
17 m W	56 ft W	250		Partly covered.
16	52	300		
15	49	300	50	Outcrop is stained with limonite and contains abundant carbonaceous twigs.
14	46	300	50	Do.
13	43	400	50	
12	39	600		
11	36	700	90	
10	33	300		
9	30	—		Covered.
8	26	250		Partly covered.
7	23	300		Do.
6	20	350		Do.
5	16	300		Do.
4	13	450		Do.
3	10	550		
2	7	450	100	Note: Overlying oxidized sandstone here yields 30 ppm eU.[3]

Table 26. *(Continued)*

Location (relative to channel-sample site)		Counts per second[1]	eU (ppm)[2]	Comments
1 m W	3	500		In underhang.
0	0	700	90	Channel-sample site; 50 ppm U_3O_8 by assay. Scintillometer was held partway in underhang.
1 m E	3 ft E	700		
2	7	700	90	
3	10	500		
4	13	550		
5	16	250		End of outcrop. Three fox kits inhabited the area just to the east of where mineralization is lost beneath float. Outcrops to the east of the fox den are oxidized.

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[1] Data were collected using a Mt. Sopris SC–132 scintillometer.

[2] For the project area, the radiometric field assays are typically high by a factor of two relative to chemical assays.

[3] The possible presence of approximately 15 ppm U_3O_8 (30 ppm eU ÷ 2) in oxidized rock is worthy of note. In this area, the transition from reduced sandstone below to oxidized sandstones above is gradational. A channel sample and semiquantitative emission spectrographic analysis are recommended.

1.5 m (5 ft) thick wherever well exposed. Typically, the gray sandstone has a radioactivity of about 0.1 "mR/hr," but radioactivities of 0.2 "mR/hr" were noted at several places.

Although continuity cannot be proven, it seems likely that a moderate amount of uraniferous reduced rock was removed by erosion in the northeast-trending hollow between this occurrence and the remainder of the Strawbridge group to the southeast.

Table 27. *Stratigraphic Section of Catskill Formation Rocks at the Strawbridge Northwest Uranium-Copper Lens*

Exposure is on the east side of the overhang and above the east side of the overhang.

Thickness (cm)	Radioactivity ("mR/hr")	Lithologic description
>150	.05	Grayish-red (5R4/2), fine-grained sandstone in undulating, thin to medium beds. Unit contains abundant pits, which are circular, 0.4 to 2 cm in diameter, and elongated up to 2 by 8 cm; they are most numerous in the upper half of the unit where shale chips have weathered. Radioactivity from above the overhang is anomalously high for oxidized sandstone.

Table 27. *(Continued)*

Thickness (cm)	Radioactivity ("mR/hr")	Lithologic description
180	.08	Medium-gray (N5), fine-grained, micaceous sandstone in undulating, thin to medium beds; gradational to oxidized colors near the top. Lenses of coarse calcareous breccia containing medium-gray (N5) shale chips up to 5 by 24 cm occur immediately above 8 cm of calcareous sandstone located at the base of the unit. The unit contains abundant gray shale chips near the middle, and trace malachite. Calcareous sandstone float containing primary and secondary copper minerals from the floor below the overhang is probably from the base of this unit. The 55-cm-thick, 0.12-"mR/hr" (average), assayed sandstone sample is from the bottom portion of the 1.80-m-thick unit.
>20	.06	Grayish-olive (10Y4/2) interbedded siltstone and fine-grained sandstone which is pitted and contains abundant brown and black oxidation products near the top.

BEAVER LAKE CLUSTER

Copper Hollow North Frost Wedge Copper-Uranium Occurrence

1. LOCATION:
   (a) The occurrence is located on the Cleon Myers farm in the southeast portion of Copper Hollow (Plates 1 and 4), the north-south-trending hollow on the west side of Barrett ("Bad") Hill. The prospect is 0.62 km (0.38 mi) northwest of the confluence of the east and west branches of the headwaters of Beaver Run and 1.11 km (0.69 mi) southwest of the outlet of Beaver Lake, Penn Township, Lycoming County. The occurrence is 8.0 m (26 ft) S80°E of the trail up Copper Hollow at a point 55.5 m (182 ft) S3°E along the same trail from the Copper Hollow 1 uranium-copper prospect. The mineralized horizon is 3.1 ± 0.2 m (10.2 ± 0.7 ft) higher in elevation than the trail and about 105 ± 10 m (345 ± 33 ft) north-northwest of where the trail intersects Cleon Myers' private road to the pasture on the top of Barrett Hill. The occurrence can best be found by searching for the small frost-wedged outcrop on the east side of this trail.
   (b) Latitude: 41°17′16″N
   Longitude: 76°36′04″W
2. ASSAYS: No channel samples were collected because the mineralized zone is only 2.6 m (8.5 ft) wide, using a cutoff of 0.07 "mR/hr."
3. MINERALOGY:
   (a) Major: None.

(b) Minor: Malachite as crusts, typically in and/or near "chalcocite" partial replacements of carbonaceous plant fragments.

(c) Trace: "Chalcocite" as partial replacements of carbonaceous plant fragments, and as micrograins in calcareous breccia and sandstone; cross-fiber quartz as perimeter replacements of carbonaceous plant fragments; calcite or aragonite as cross-fiber veinlets cutting partial replacements of carbonaceous plant fragments by "chalcocite"; brochantite as emerald-green microcrystals, sometimes in stalactitic growths, in vugs where "chalcocite" has oxidized; "apatite" as phosphatic fish remains; azurite as rare crusts; and chrysocolla.

4. GEOLOGIC DESCRIPTION: The occurrence consists of a natural outcrop of reduced, mineralized calcareous breccia, sandstone, and siltstone near the base. This reduced zone is approximately 35 cm (14 in.) thick and is mineralized over a length of 2.6 m (8.5 ft), using a cutoff of 0.07 "mR/hr." The calcareous breccia has an average radioactivity of approximately 0.1 "mR/hr," but it includes carbonaceous plant fragments up to several centimeters long that have radioactivities up to 0.43 "mR/hr." The calcareous breccia is underlain by gray siltstone and overlain by oxidized fine-grained sandstone.

The occurrence is of interest only in helping to establish the existence of a horizon that has intermittent mineralization.

Copper Hollow 1 Uranium-Copper Prospect

1. LOCATION:

(a) The prospect is located on the Cleon Myers farm on the east side of Copper Hollow (Plates 1 and 4), the north-south-trending hollow on the west side of Barrett ("Bad") Hill. The prospect is 0.73 km (0.45 mi) northwest of the confluence of the east and west branches of the headwaters of Beaver Run and 1.05 km (0.65 mi) southwest of the outlet of Beaver Lake, Penn Township, Lycoming County. The reference point is an inclined drill hole[1] in an outcrop on the east side of a N15°W-trending trail at a point 55.5 m (182 ft) approximately N3°W of the Copper Hollow North Frost Wedge copper-uranium occurrence and 65.5 m (215 ft) approximately S10°E of the Copper Hollow 2 prospect. This places the inclined drill hole 49.2 m (161 ft) S64°E of the huge white ash tree (Plate 4). Following the latter bearing, one would cross the trail 32 m (105 ft) from the tree.

(b) Latitude: 41°17′20″N
Longitude: 76°36′04″W

2. ASSAYS: A 48-cm (19-in.) channel sample of gray sandstone, siltstone, and calcareous breccia contains 128 ppm U_3O_8 and 1.15 percent copper. The sample had an average radioactivity of 0.09 "mR/hr" and yielded a radiometric assay of 100 ppm eU. See sample MHK 765, Appendix 3.

3. MINERALOGY:

(a) Major: None.

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[1] This hole has an inclination of 47 degrees in a direction of N75°E.

(b) Minor: Malachite in calcareous breccia, on gray sandstone bedding partings, and in and/or near carbonaceous plant fragments.

(c) Trace: Azurite; "chalcocite"; barite as colorless to golden-yellow tabular microcrystals associated with malachite in vugs in a "chalcocite" replacement of a carbonaceous plant fragment; quartz as colorless micrograins in "chalcocite"; and calcite as white secondary crusts associated with malachite.

4. GEOLOGIC DESCRIPTION: The prospect consists of outcrop faces, having a total length of approximately 25 m (80 ft), which have been drilled and blasted. A schematic plan view of the faces is illustrated in Figure 33.

As shown in Figure 33, the radioactivity of the mineralized horizon is relatively uniform over a few meters compared with most of the occurrences in the area. From 2 m (6 ft) northeast of the corner to 2.9 m (9.5 ft) south of the reference point, the radioactivity is typically ≥ 0.07 "mR/hr." Within this interval, from the reference point north to the same corner, the average radioactivity is typically 0.1 "mR/hr." Overall, this radioactive zone contains relatively more calcareous breccia and sandstone to the north and relatively more siltstone to the south. Typically, the mineralized horizon is on the order of 10 cm (4 in.) thick, but tends to be quite variable in thickness and to change slightly in stratigraphic position. The mineralized horizon consists of interbedded sandstone and calcareous breccia that contains lenses of crossbedded sand-

Table 28. *Stratigraphic Section of Catskill Formation Rocks at Copper Hollow 1 Uranium-Copper Prospect*

Exposure is 0.4 m (1.3 ft) north of the reference point (angle drill hole).

Thickness (cm)	Radioactivity ("mR/hr")	Lithologic description
>100	.015	Grayish red (5R4/2) near the top, and transitional to brownish gray (5YR4/1) near the bottom. Fine-grained, thin- to medium-bedded, micaceous sandstone.
4	.025	Medium-dark-gray (N4), fine-grained, micaceous sandstone.
25	.07	Medium-gray (N5) calcareous breccia containing fine-grained sandstone laminae, and carbonaceous plant fragments accompanied by "chalcocite," malachite, and trace azurite. This unit and the top 23 cm of the lower unit are included in the 48-cm-thick assayed sample.
49	.06 Variable	Medium-gray (N5), fine-grained, highly indurated, thick-bedded sandstone with interbedded dark-greenish-gray (5GY4/1) siltstone containing trace malachite.
36	.03	Grayish-red (5R4/2) siltstone and fine-grained sandstone mottled with transitional colors of oxidation.
>15	.025	Grayish-red siltstone.

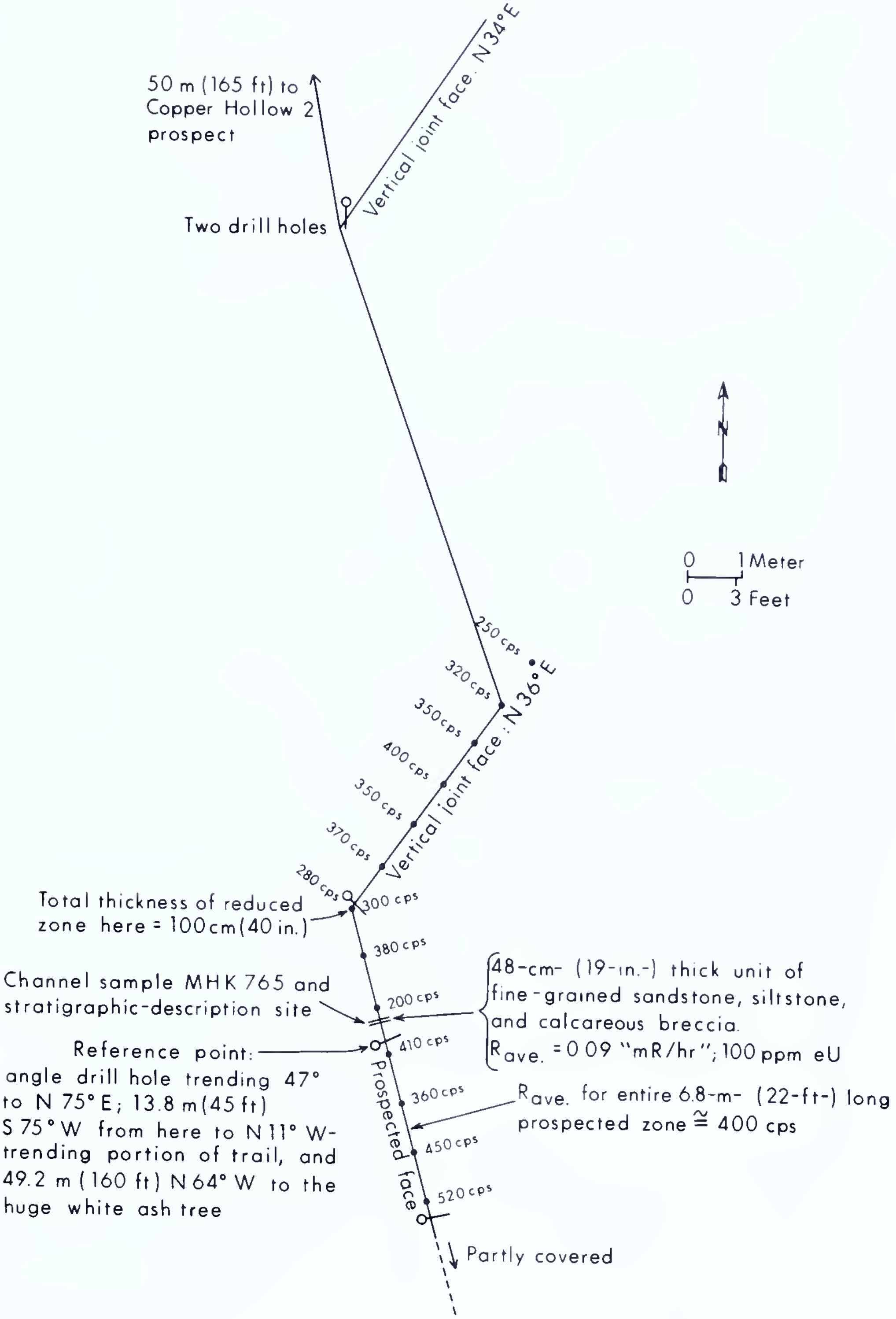
Vertical joint face: N34°E
50 m (165 ft) to Copper Hollow 2 prospect
Two drill holes
N
0 1 Meter
0 3 Feet
250 cps
320 cps
350 cps
400 cps
350 cps
370 cps
280 cps
Vertical joint face: N 36°E
Total thickness of reduced zone here = 100 cm (40 in.)
300 cps
380 cps
Channel sample MHK 765 and stratigraphic-description site
200 cps
48-cm- (19-in.-) thick unit of fine-grained sandstone, siltstone, and calcareous breccia. $R_{ave.}$ = 0.09 "mR/hr"; 100 ppm eU
Reference point: angle drill hole trending 47° to N 75° E; 13.8 m (45 ft) S 75° W from here to N 11° W-trending portion of trail, and 49.2 m (160 ft) N 64° W to the huge white ash tree
410 cps
Prospected face
360 cps
$R_{ave.}$ for entire 6.8-m- (22-ft-) long prospected zone ≅ 400 cps
450 cps
520 cps
Partly covered

Figure 33. Schematic plan map of Copper Hollow 1 uranium-copper prospect, 1 km (0.6 mi) southwest of the outlet of Beaver Lake, Penn Township, Lycoming County.

stone. The stratigraphy at the channel-sample site is described in Table 28.

The Copper Hollow 1 uranium-copper prospect is one of the richer prospects in the area and is relatively well exposed. Mineralization in a variety of intimately associated lithologies suggests that detailed sampling on a lithologic basis may be warranted in order to determine the relative enrichment factors for uranium, copper, and other elements.

Copper Hollow 2 Prospect

1. LOCATION:
   (a) The prospect is located on the Cleon Myers farm on the east side of Copper Hollow (Plates 1 and 4), the north-south-trending hollow on the west side of Barrett (''Bad'') Hill. The prospect is 0.78 km (0.48 mi) north-northwest of the confluence of the east and west branches of the headwaters of Beaver Run and 1.03 km (0.64 mi) southwest of the outlet of Beaver Lake, Penn Township, Lycoming County. The reference point for the prospect, the center of an approximately N50°W trending face at the head of the trench, is 63.5 m (208 ft) S82°E of the adit at McCauley prospect 20 and 65.5 m (215 ft) approximately N10°W of the inclined drill hole at the Copper Hollow 1 prospect. This places the Copper Hollow 2 prospect 55.5 m (182 ft) N35°E of the huge white ash tree (*Fraxinus americana*) located on the east side of the creek and approximately 10 m (30 ft) southwest of the trail.
   (b) Latitude: 41°17′22″N
   Longitude: 76°36′04″W
2. ASSAYS: No channel samples were collected because of the extremely lean mineralization. The maximum radioactivity observed, 0.2 ''mR/hr,'' was very localized. The only mineralized zone capable of yielding a channel sample had an average radioactivity of only 0.07 ''mR/hr'' and a maximum of 0.08 ''mR/hr.'' At this latter spot, on the N50°W-trending face near the floor of the trench, a radiometric assay of 170 ppm eU was obtained. This is, however, believed to be spurious because of geometric problems.
3. MINERALOGY:
   (a) Major: None.
   (b) Minor: None.
   (c) Trace: In calcareous sandstone and calcareous breccia from the dumps—''apatite'' as phosphatic fish remains, including a crossopterygian tooth fragment; chalcopyrite, bornite, and ''chalcocite'' as interstitial micrograins, and as replacements of phosphatic fish remains and filling of fossae[1]; galena as rare partial replacements of

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[1] Secondary copper on these dumps tends to be associated with ''apatite'' rather than carbonaceous limbs. Secondary uranium and daughter elements show the reverse association. Measurements with a Geiger counter yield up to 0.17 ''mR/hr'' on a ''limonite''-stained carbonaceous limb lacking copper bloom, but only background readings on apatite.

the "apatite"; and malachite as stainings in the "apatite" and coatings.

4. GEOLOGIC DESCRIPTION: The prospect consists of an approximately 5 m (16 ft) long, N50°W-trending face and a N85°W- (near face) to N75°W- (near dumps) trending trench having associated dumps around its west end.

   The face at the head of the trench exposed a 4.2-m- (14-ft-) thick reduced zone consisting mostly of thin- to medium-bedded, fine-grained, gray sandstone, some of which is calcareous near the base. From the prospect, the reduced zone can be traced northwest as far as the creek, but is essentially barren. Similarly, the swampy area between Copper Hollow 2 and 3 prospects yields only 110 cps (with the scintillometer slung from the shoulder). This swamp, however, would be slightly below the theoretical horizon of the reduced zone.

   Bedding in the area is estimated to strike N75°E and dip 13°N, and subvertical joints trend N38°E.

   The occurrence is of value only in demonstrating the extent of copper prospecting in the area and in helping to define an intermittently mineralized horizon.

Copper Hollow 3 Uranium-Copper Prospect
(McCauley Prospect 20)

1. LOCATION:
   (a) The prospect is located on the Cleon Myers farm on the west side of Copper Hollow (Plates 1 and 4), the north-south-trending hollow on the west side of Barrett ("Bad") Hill. The prospect is 0.79 km (0.49 mi) northwest of the confluence of the east and west branches of the headwaters of Beaver Run and 1.06 km (0.66 mi) southwest of the outlet of Beaver Lake, Penn Township, Lycoming County. The reference point for the prospect, a shallow drill hole above the center of the adit entrance, is 63.5 m (208 ft) N82°W of the Copper Hollow 2 prospect, 12.5 m (41 ft) N31°E of the Copper Hollow 4 prospect, 38.4 m (126 ft) N1°W of the calcareous-breccia–brick dump, and 6.7 m (22 ft) west of a N13°E-trending trail.
   (b) Latitude: 41°17′22″N
   Longitude: 76°36′07″W
2. ASSAYS: No channel samples were collected because of the extremely localized nature of mineralization. For example, the area of maximum radioactivity observed, 0.5 "mR/hr" near a drill hole in the south side, is less than 10 cm (4 in.) across. The only mineralized zone capable of yielding a channel sample had an average radioactivity of only 0.06 "mR/hr."
3. MINERALOGY:
   (a) Major: None.
   (b) Minor: Malachite.
   (c) Trace: None.

4. GEOLOGIC DESCRIPTION: The prospect consists of a wide, shallow adit which seems to have been prospected during the late 1950's (Figure 34). The "long" axis of the adit trends roughly N65°W for 3.0 m (10 ft). The width of the adit at the entrance is 3.0 m (10 ft) and, in plan view, the back of the adit is somewhat concave. The height at the entrance is 1.85 m (6 ft) and at the back it is 1.65 m (5.4 ft).

The stratigraphy exposed in the adit can be summarized from the top down as follows: 110 cm (43 in.) of fine-grained, micaceous, gray sandstone that has an average radioactivity of 0.03 "mR/hr" and is partly oxidized near the top; 38 cm (15 in.) of gray calcareous breccia that has an average radioactivity of 0.03 "mR/hr"; and 20 cm (8 in.) of fine-grained, micaceous, oxidized sandstone that has an average radioactivity of 0.02 "mR/hr." Bedding in the vicinity of the adit trends approximately N50°W and dips 6°NE. The pronounced joint above the entrance to the adit trends N31°E and dips 81°SE.

In addition to the previously mentioned radioactive spot, there is a second small spot in calcareous breccia in the back of the adit which yields 0.15 "mR/hr" and a small cutout in the northern portion of the back of the adit which yields 0.06 "mR/hr" (average) and 0.13 "mR/hr" (maximum). Malachite is moderately abundant in this small cutout on the upper contact of a calcareous breccia with a gray sandstone. In the opinion of the authors, the occurrence is of value only in demonstrating the lateral extent of intermittent, minor mineralization at a given horizon. Based on McCauley's (1961, p. 61) description, the adit at one time contained "chalcocite" replacements of carbonaceous plant

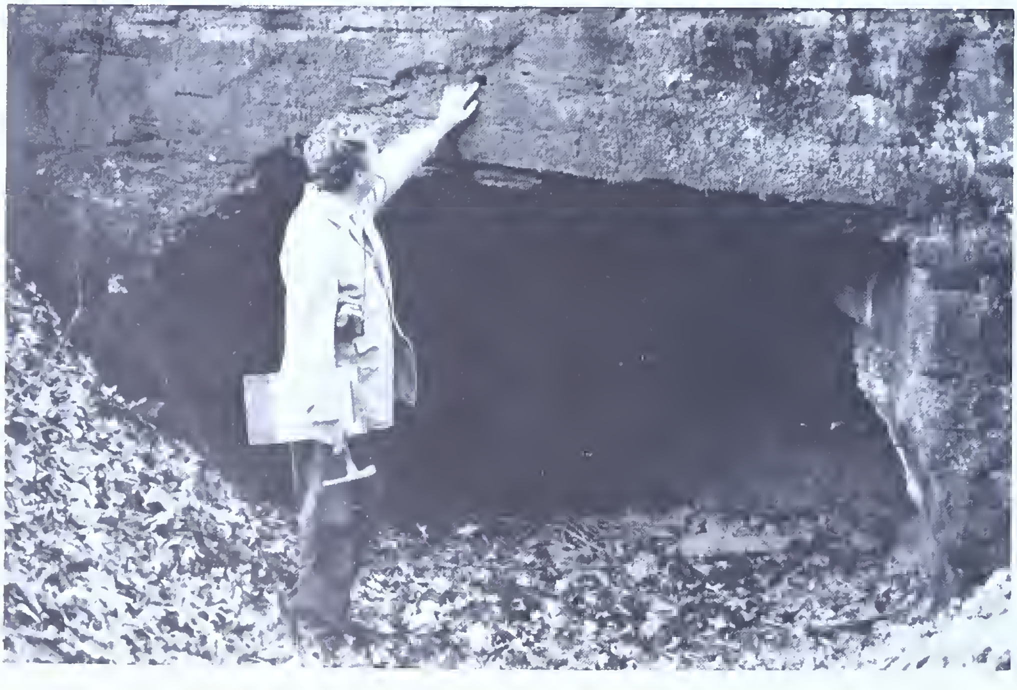

Figure 34. Geologist at entrance to Copper Hollow 3 uranium-copper prospect (McCauley prospect 20).

fragments at the base of a gray sandstone overlying shale. These were reported to have radioactivities of up to 1.5 "mR/hr." In view of McCauley's differing observations, it seems likely that a small amount of additional excavating was done after his visit in 1956 or 1957. This, together with the extremely spotty nature of the occurrence, may account for the difference between the descriptions.

Copper Hollow 4 Prospect

1. LOCATION:
    (a) The prospect is located on the Cleon Myers farm on the west side of Copper Hollow (Plates 1 and 4), the north-south-trending hollow on the west side of Barrett ("Bad") Hill. The prospect is 0.78 km (0.48 mi) northwest of the confluence of the east and west branches of the headwaters of Beaver Run and 1.1 km (0.68 mi) southwest of the outlet of Beaver Lake, Penn Township, Lycoming County. The head of the trench at Copper Hollow 4 prospect is 12.5 m (41 ft) S31°W of the center of the adit at Copper Hollow 3 uranium-copper prospect and 28.7 m (94 ft) N14°W of the calcareous-breccia-brick dump.
    (b) Latitude: 41°17′21″N
    Longitude: 76°36′07″W
2. ASSAYS: No channel samples were collected because the exposed reduced zone and dumps are essentially barren.
3. MINERALOGY: No mineralization was observed.
4. GEOLOGIC DESCRIPTION: The prospect consists of a joint face that trends N31°E and dips 88°SE at the head of a 5.3-m- (17-ft-) long trench that trends approximately N60°W. The thickness of the exposed reduced zone at the joint face is $\geq$ 0.8 m (2.6 ft), but its radioactivity is only 0.03 ± 0.01 "mR/hr." The dumps are essentially barren of copper and yield only 0.025 "mR/hr." Bedding in the area of the prospect trends N75°E and dips 10°N. The occurrence is useful only to help trace the reduced horizon or as a possible site for a background reduced sample.

Copper Hollow 5A and 5B Prospects

1. LOCATION:
    (a) The prospects are located on the Cleon Myers farm on the west side of Copper Hollow (Plates 1 and 4), the north-south-trending hollow on the west side of Barrett ("Bad") Hill. The prospects are 0.76 km (0.47 mi) northwest of the confluence of the east and west branches of the headwaters of Beaver Run and 1.12 km (0.70 mi) southwest of the outlet of Beaver Lake, Penn Township, Lycoming County. From the reference point at Copper Hollow 5A prospect, which is the southwest overhanging corner of the adit, to the 5B prospect is 17.5 m (57.4 ft) in a direction of S35°W. From the reference point at Copper Hollow 6 prospect, which is the center of the trench approx-

imately 2 m (7 ft) southeast of the face above the undercut, to the 5B prospect is 34 m (112 ft) in a direction of N47°E.

(b) Latitude: 41°17′20″N
Longitude: 76°36′08″W

2. ASSAYS: A 56-cm (22-in.) channel sample of calcareous breccia and minor gray siltstone contains 11 ppm U_3O_8 and 3,400 ppm copper. A radiometric assay of this unit yielded 30 ppm eU, and the overlying reduced sandstone yielded 50 ppm eU. See sample MHK 766, Appendix 3.
3. MINERALOGY:

   Copper Hollow 5A prospect
   (a) Major: None.
   (b) Minor: None.
   (c) Trace: Malachite, some associated with azurite, on sandstone bedding partings and in calcareous breccia; "chalcocite" in calcareous breccia[1] as micrograins and partial replacements of phosphatic fish remains and carbonaceous plant fragments; "apatite" as phosphatic fish remains; calcite or aragonite as cross-fiber veinlets in rich "chalcocite" replacements; rare chrysocolla; and an unidentified yellow-brown secondary uranium mineral on a carbonaceous plant fragment from a small "maroon" zone near the base of the channel-sample cut.

   Copper Hollow 5B prospect
   (a) Major: None.
   (b) Minor: None.
   (c) Trace: Malachite as coatings; rare "chalcocite" as a partial replacement of carbonaceous plant fragments; and "apatite."
4. GEOLOGIC DESCRIPTION: The partly caved adit at Copper Hollow 5A prospect would have originally been 4.8 m (15.7 ft) long and 2.8 m (9.2 ft) wide at the back. The uncaved southwest portion is 1.7 m (5.8 ft) long. The original trend of the adit would have been approximately N60°W.

   Copper Hollow 5B prospect consists of an approximately 6 m (20 ft) long prospected face characterized by one half of an inclined drill hole and an unobtrusive horizontal hole. The average thickness of the reduced zone is approximately 70 cm (28 in.) near the center, but the zone thins toward the southwest. Phosphatic fish remains and malachite occur in calcareous breccia which has relief on its lower contact (i.e., it has an erosional contact with the underlying red beds). The average radioactivity of the reduced face is only 0.03 "mR/hr." Bedding in the area of the 5B prospect trends N60°W and dips 7°N.

   Taken together, the 5A and 5B prospects help define an extensive, though apparently leanly mineralized, horizon in Copper Hollow.

   The reduced zone exposed on the southwest side of the adit entrance is slightly greater than 1 m (3 ft) thick. Of this, the upper 55 ± 5 cm (22 ± 2 in.) is typically sandstone and the lower 50 ± 5 cm (20 ± 2 in.) is cal-

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[1] The richest copper mineralization was noted in calcareous breccia from the 5A dumps, which may represent "ore" from several nearby prospects.

Table 29. *Stratigraphic Section of Catskill Formation Rocks at Copper Hollow 5A Prospect*

Exposure (1) is above the roof of the partly caved adit at the southwest corner entrance; exposure (2) is on the southwest face of the partly caved adit, 1.5 m (4.9 ft) northwest of the southwest corner entrance.

	Thickness (cm)	Radioactivity (''mR/hr'')	Lithologic description
(1)	>110	.02	Between grayish red (5R4/2) and grayish red purple (5RP4/2). Fine-grained, thin-bedded sandstone. Slightly reduced at the base of the unit.
(2)	52	.04	Medium-gray (N5), fine-grained, thin-bedded sandstone containing carbonaceous plant fragments, malachite, and azurite near the top of the unit.
	47	.04	Medium-gray (N5) calcareous breccia containing trace malachite and ''chalcocite.'' This assayed unit included, near the base, a small ''maroon''-colored zone that had 0.3-''mR/hr'' maximum radioactivity in a 5-cm area.
	7	.04	Dark-greenish-gray (5G4/1) siltstone mottled with colors of oxidation, and medium-dark-gray (N4) shaly laminae at the top which contain abundant malachite. The bottom portion of the 56-cm-thick assayed sample is from this unit.
	>5	.03	Siltstone, between grayish red (5R4/2) and dusky red (5R3/4); slightly mottled with colors of reduction.

careous breccia, both having an average radioactivity of 0.04 ''mR/hr.'' The detailed stratigraphy is described in Table 29, but it should be noted here that the carbonaceous plant fragments and associated malachite are from the reduced sandstone. Except for an extremely local reading of 0.3 ''mR/hr,'' the maximum radioactivity observed in the accessible adit was 0.1 ''mR/hr.''

The dump located 18 m (59 ft) S67 °E of the reference point and 5.2 m (17 ft) lower in elevation contains many hand samples that have radioactivities of about 0.1 ''mR/hr.'' The dump is moderately rich in copper and uranium, suggesting that either the caved portion was richer or that the material on the dump was transported from a more distant prospect. The rock on the dump consists of calcareous breccia containing ''chalcocite'' as a replacement of medium to large carbonaceous plant fragments. Typically these fragments have radioactivities of 0.1 ''mR/hr,'' but the radioactivities range up to 1.5 ''mR/hr.'' Fragments that are similar in appearance but less radioactive have been found in the partly caved adit.

Cleon Myers (personal communication, November 22, 1978) reported that a small ash-slag(?) pile located 14.3 m (47 ft) N1 °W of the calcareous breccia dump is at the side of an old copper smelter. This, he reported, was enclosed in a frame building with clapboard roof, and a blacksmith shop on the flat just to the south supported the operation.

Efforts to identify the nature of the slag-ash by X-ray powder diffractometer scans failed because of the complexity of the pattern and unfamiliarity with such materials. The presence of firebrick[1] in the calcareous breccia dump supports Mr. Myers' personal observations and suggests that the "ore" could have been a stockpile for processing, rather than a dump from the nearby 5A prospect.

Bedding in the area of the 5A prospect trends approximately N60°W, and dips 4°N. The joint face trends N37°E and dips 87°SE.

Copper Hollow 6 Prospect

1. LOCATION:

(a) The prospect is located on the Cleon Myers farm on the southwest side of Copper Hollow (Plates 1 and 4), the north-south-trending hollow on the western side of Barrett ("Bad") Hill. The prospect is 0.78 km (0.48 mi) northwest of the confluence of the east and west branches of the headwaters of Beaver Run and 1.12 km (0.70 mi) southwest of the outlet of Beaver Lake, Penn Township, Lycoming County. From the drill hole at Copper Hollow 5B prospect, it is approximately 34 m (112 ft) in a direction of S47°W to the reference point at Copper Hollow 6 prospect; this reference point is in midair

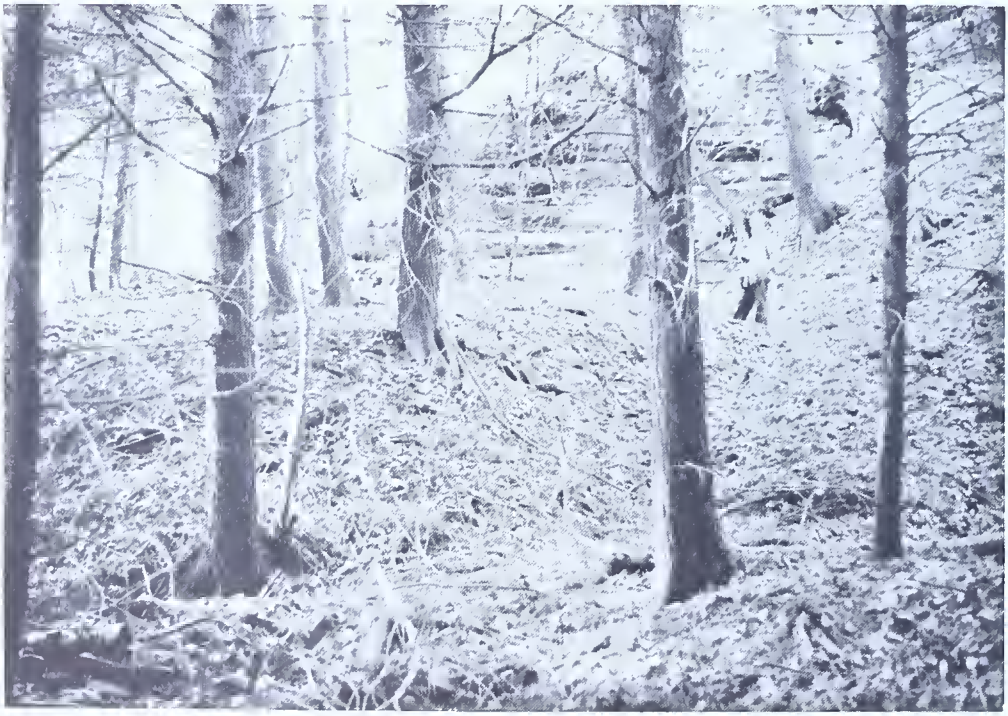

Figure 35. View looking west at moderately large, overgrown dumps, Copper Hollow 6 area. See Figure 36 for a closer view.

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[1] These bricks are marked "Queens Run." See the section on history of prospecting in the area, p. 4.

in the center of the trench about 2 m (7 ft) southeast of the joint face above the undercut at the head of the trench. The reference point is 37 m (121 ft) N73°E of Copper Hollow 7 prospect.

(b) Latitude: 41°17′20″N
Longitude: 76°36′09″W

2. ASSAYS: A 47-cm (18.5-in.) channel sample of medium-grained sandstone and calcareous breccia contains 12 ppm U_3O_8 and 5,350 ppm copper. See sample MHK 729, Appendix 3.
3. MINERALOGY:
   (a) Major: None.
   (b) Minor: Malachite on gray sandstone bedding partings, in and/or near carbonaceous plant fragments; also in calcareous breccia associated with phosphatic fish remains, on an *Archanodon* fossil (William Penn Memorial Museum specimen I 1194), and as crusts.
   (c) Trace: "Chalcocite" as sparse, fine-grained masses that have rare bornite, as replacements of phosphatic fish remains in calcareous

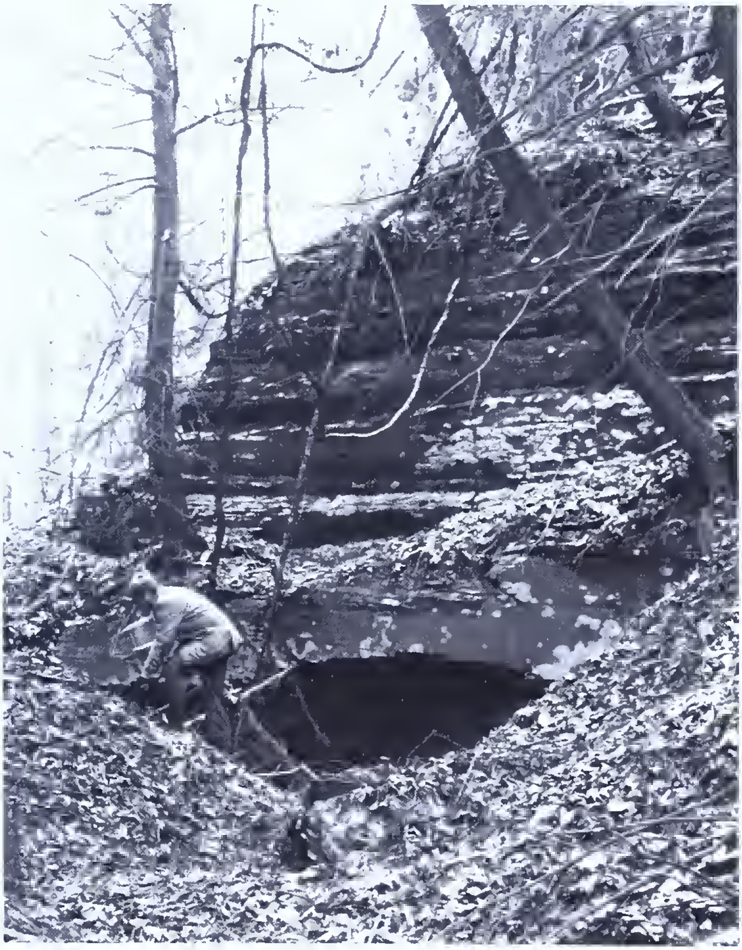

Figure 36. View looking west at a small overhang/incipient adit at the west end of a dump-surrounded trench, Copper Hollow 6 area.

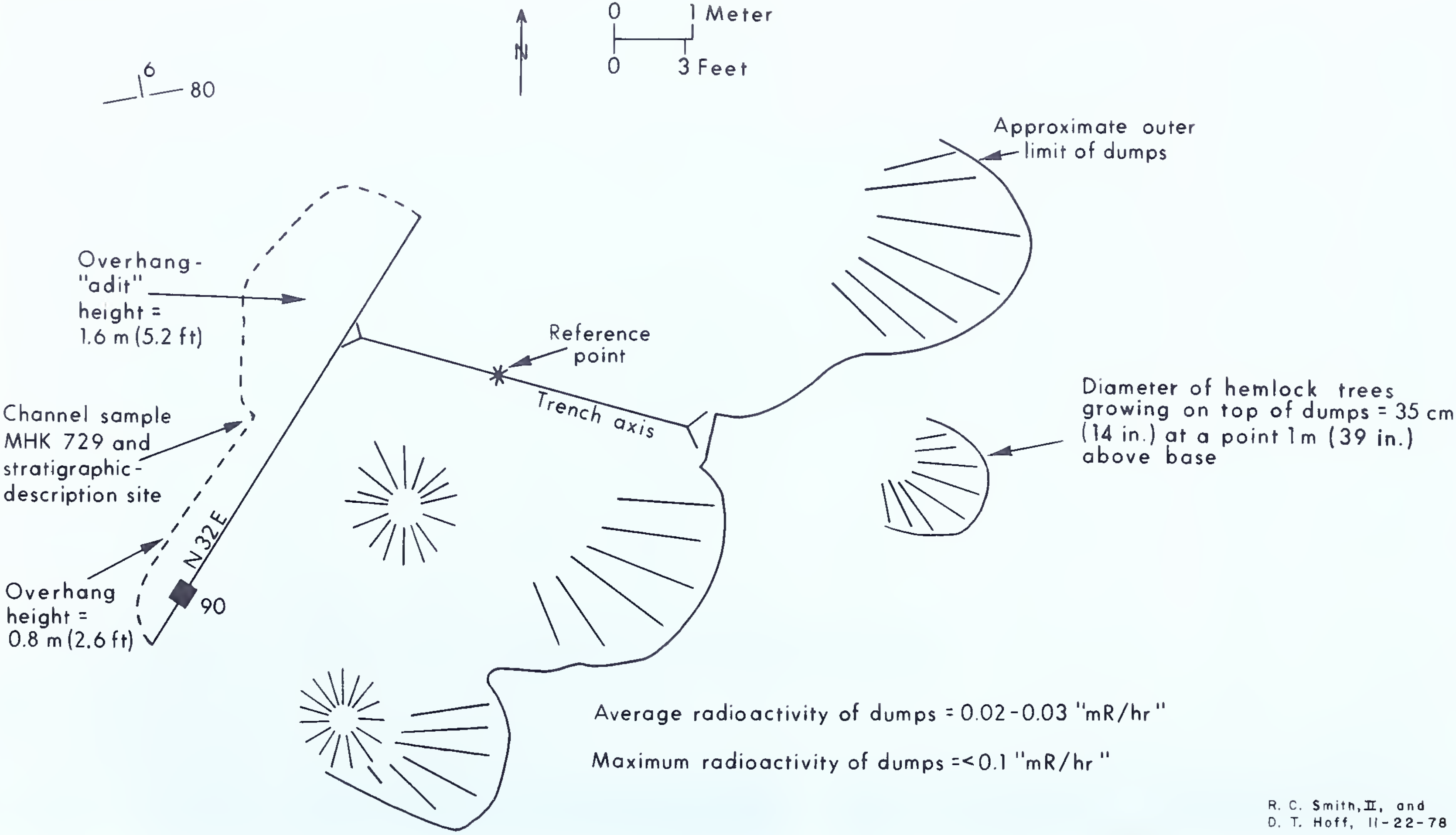
6
80
N
0
1 Meter
0
3 Feet
Approximate outer limit of dumps
Overhang-"adit" height = 1.6 m (5.2 ft)
Reference point
Trench axis
Diameter of hemlock trees growing on top of dumps = 35 cm (14 in.) at a point 1m (39 in.) above base
Channel sample MHK 729 and stratigraphic-description site
N32E
90
Overhang height = 0.8 m (2.6 ft)
Average radioactivity of dumps = 0.02-0.03 "mR/hr"
Maximum radioactivity of dumps =<0.1 "mR/hr"
R. C. Smith, II, and
D. T. Hoff, 11-22-78

Figure 37. Schematic plan map of Copper Hollow 6 prospect, Cleon Myers farm, 1.1 km (0.68 mi) southwest of the outlet of Beaver Lake, Penn Township, Lycoming County. Note the large apparent area of dumps relative to the overhang adit

breccia; "apatite" as phosphatic fish remains; azurite on bedding partings; and chrysocolla as green crusts on gray sandstone bedding partings and in calcareous breccia.

4. GEOLOGIC DESCRIPTION: Copper Hollow 6 prospect is somewhat enigmatic because of the moderately large size of the dumps relative to the excavations (Figures 35 to 37). The overhang/incipient adit is 3.5 m (11.5 ft) wide at the entrance, 1.6 m (5.2 ft) high, and about 1.5 m (4.9 ft) deep. It was developed in a N32°E-trending joint face. From the southwestern corner of this "adit," which is the channel-sample and stratigraphic-description site, to 3 m (10 ft) in a direction of S32°W, there is a continuous excavation about 0.8 m (2.6 ft) in height and about 0.5 m (1.6 ft) in depth (Figure 37). The relatively large dumps occur to the east of these excavations. These dumps have average radioactivities of only 0.02 to 0.03 "mR/hr," and maximum radioactivities of less than 0.1 "mR/hr." Their copper content could, however, exceed 0.05 percent. Hemlock trees growing on top of these dumps are 35 cm (14 in.) in diameter at a point 1 m (39 in.) above the base. This suggests that mining occurred more than 50 years ago, but tree coring would be needed for a reliable estimate.

Table 30. *Stratigraphic Section of Catskill Formation Rocks at Copper Hollow 6 Prospect*

Exposure (A) is above the roof of the overhang/incipient adit at the southwest corner; exposure (B) is on the southwest-corner face of the overhang/incipient adit.

	Thickness (cm)	Radioactivity ("mR/hr")	Lithologic description
(A)	>100	.025	Grayish-red (5R4/2), fine-grained, micaceous, laminated to medium-bedded, slightly crossbedded sandstone. The unit is between grayish red (5R4/2) and blackish red (5R2/2) at the base.
(B)	59	.025	Dark-greenish-gray (5GY4/1), medium-grained, thin- to medium-bedded sandstone; medium dark gray (N4) near the top.
	47	.07 .13 max.	Dark-greenish-gray (5GY4/1), medium-grained, micaceous sandstone containing dark-greenish-gray (5GY4/1) shale chips. Calcareous breccia, between medium gray (N5) and medium dark gray (N4), is interbedded with the sandstone, and approximately 24 cm of calcareous breccia occurs at the base of the unit. This assayed unit contains "chalcocite" and abundant malachite. Two meters S32°W from the southwest corner of the adit, this ore zone lacks calcareous breccia and contains abundant carbonaceous plant fragments, malachite, trace azurite, and a 0.14-"mR/hr" maximum radioactivity.
	>60	.025	Grayish-red (5R4/2), fine-grained, micaceous, medium-bedded sandstone; medium dark gray (N4) near the top.

The reduced zone exposed on the southwest side of the overhang/adit is 106 cm (42 in.) thick. The stratigraphy at this site is described in Table 30. The median strike of bedding in the bluff to the west of the prospect is N80°E and the median dip is 6°N; there is a moderate range of strikes but not dips.

The extremely erratic, low radioactivities at the occurrence confirm the assay results that the occurrence is not of economic interest with respect to uranium mineralization.

Copper Hollow 7 Prospect

1. LOCATION:
   (a) The prospect is located on the Cleon Myers farm on the southwest side of Copper Hollow (Plates 1 and 4), the north-south-trending hollow on the western side of Barrett ("Bad") Hill. The prospect is 0.78 km (0.48 mi) northwest of the confluence of the east and west branches of the headwaters of Beaver Run and 1.15 km (0.71 mi) southwest of the outlet of Beaver Lake, Penn Township, Lycoming County. The reference point for Copper Hollow 7 prospect, located on the center of the face above the trench, is approximately 37 m (121 ft) S73°W of Copper Hollow 6 prospect. From the center of the caved adit of Copper Hollow 8 prospect, Copper Hollow 7 prospect can be located by first proceeding 27 m (89 ft) on a bearing of S83°E, and then 21 m (69 ft) on a bearing of N69°W.
   (b) Latitude: 41°17′20″N
   Longitude: 76°36′10″W
2. ASSAYS: No channel samples were collected because of the extremely lean nature of uranium mineralization. The average radioactivity of the dump on contact is only 0.02 to 0.03 "mR/hr." Sparse malachite-stained plant fragments have radioactivities up to 1.5 "mR/hr."
3. MINERALOGY:
   (a) Major: None.
   (b) Minor: Malachite on fluted bedding surfaces in fine-grained sandstone and associated with fossil plant fragments.
   (c) Trace: Chrysocolla as olive-, medium-, and bluish-green crusts in and/or near fossil plant fragments, and metazeunerite–meta-uranospinite series as pale-green micaceous aggregates, fluorescent pale-green (UV, short wave and long wave), on fracture surfaces.
4. GEOLOGIC DESCRIPTION: Copper Hollow 7 prospect consists of an approximately 5.5 m (18 ft) long, N18°-20°W-trending trench. An hour of digging by one of the authors at the northwest head of the trench failed to reveal evidence of an adit into the face. The trench is, however, badly slumped.

   Bedding in the bluff above Copper Hollow 7 prospect trends approximately N80°W and dips approximately 5°N. The prospect is of interest only in helping to establish the mineralized horizon.

   A slumped outcrop of sandstone and calcareous breccia located 16 m (52 ft) S69°W of Copper Hollow 7 prospect is mineralized. It appears to have come from the same horizon as the Copper Hollow 8 and 7 prospects and has a lamina up to 2 mm thick that contains disseminated uraninite and nearby "chalcocite" replacements of plant fragments, and malachite. The best chips have radioactivities of approximately 1.5 "mR/hr" but are probably not suitable for radiometric age estimates.

Copper Hollow 8 Prospect

1. LOCATION:
   (a) Copper Hollow 8 prospect is located on the Cleon Myers farm on the south end of a ridge between Copper Hollow and the west branch of Beaver Run, Penn Township, Lycoming County. There are two adits several meters in elevation above a trail which trends N80°W to the west and S87°E to the east of the adits. The adits are 23.8 ± 1 m (78 ± 3 ft) lower in elevation than a substantial flat at the top of the cliff, and are 1.18 km (0.73 mi) southwest of the outlet of Beaver Lake and 0.73 km (0.45 mi) east of the intersection of Loop Road with the Beaver Lake-Ebenezer Church road.
   (b) Latitude: 41°17′20″N
   Longitude: 76°36′11″W
2. ASSAYS: A 51-cm (20-in.) channel sample of gray siltstone and fine-grained sandstone contains 27 ppm U_3O_8 and 4,600 ppm copper. A radiometric assay yielded an estimate of 80 ppm eU, but this was beneath a large overhang of oxidized rock. See sample MHK 727, Appendix 3.
3. MINERALOGY:
   (a) Major: None.
   (b) Minor: Malachite as crusts, sometimes fibrous, on bedding partings and in and/or near copper sulfide replacements of carbonaceous limbs, all in gray siltstone and fine-grained sandstone, and in grayish-red, fine-grained sandstone.
   (c) Trace: In gray siltstone and fine-grained sandstone, and in grayish-red, fine-grained sandstone—digenite-djurleite, and "chalcocite" as partial replacements of carbonaceous limbs[1]; rare uraninite (Figure 38) as black replacements of fossil twigs[2]; secondary, greenish-yellow uranophane and zeunerite-metazeunerite or torbernite-metatorbernite as light-green to yellow-green, tabular microcrystals oc-

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[1] Examination of a polished section of one limb suggests covellite replacement of digenite along shrinkage cracks (color photograph 8), sparse areas that have blebs of bornite incompletely replaced by digenite, and sparse irregular lamellae and blebs of djurleite.

[2] One twig (20 mm (0.8 in.) long by approximately 1 mm (0.04 in.) thick), yielding 5.0 "mR/hr" and collected from approximately 2 m (7 ft) northwest of the caved adit's center, shows black uraninite(?) (not X-rayed) possessing a conchoidal to uneven fracture and a submetallic luster. Another small twig, collected in the same area and yielding 4.0 "mR/hr," contains a dark-brown, resinous to greasy material which is probably altered uraninite.

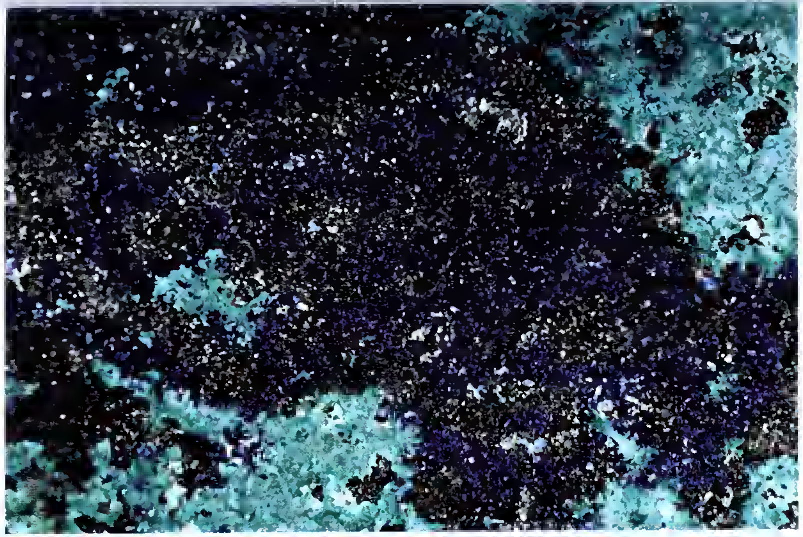
An interesting observation both in the caved adit and northwest of the caved adit was the obvious preference of copper for limbs, and of uranium for twigs. One X-rayed uraninite replacement of a twig (approximately 6 mm by 35 mm by 1 mm (0.2 by 1.4 by 0.04 in.) thick), yielding 8.0 "mR/hr" and collected in approximately 1957 from the caved adit, shows considerable secondary uranophane and only a trace of copper bloom. An 8- by 9- by 2-cm- (3.1- by 3.5- by 0.8-in.-) thick section of a limb or log from the same area, replaced by digenite and djurleite, yields a relatively meager 0.4 "mR/hr."

MINERALS FROM THE PICTURE ROCKS-SONESTOWN AREA

(William Penn Memorial Museum (WPMM) specimen numbers are shown in parentheses at end of captions. Photographs by J. H. Barnes except where noted.)

Photograph

1. Azurite (blue) and malachite (green) on reduced sandstone, McCauley prospect 17 (WPMM E198).
2. Beudantite, 15 m (50 ft) N88°W of McCauley prospect 17.
3. Cerussite as striated adamantine microcrystals (100X), Rock Run uranium occurrence. Photograph by T. W. Myers.
4. Chalcophyllite as micaceous microcrystals on reduced sandstone, southeast adit, McCauley prospect 22 (WPMM m4898).
5. Chalcophyllite as pseudohexagonal microcrystals (80X), southeast adit, McCauley prospect 22 (WPMM m4899). Photograph by T. W. Myers.
6. Chrysocolla on reduced sandstone containing carbonaceous plant fragments, Rock Run Church copper prospect (WPMM m5411).
7. Cuprosklodowskite (yellowish green) and kasolite (golden), McCauley prospect 18 (WPMM m5414).
8. Digenite (medium blue) and covellite (indigo) as replacements of a carbonaceous limb, southeast adit, Copper Hollow 8 prospect. Polished section.
9. Francevillite (canary yellow) on "limonite"-stained sandstone, 80-m site, Sonestown Nose uranium trench of Gill-Jordan.
10. Gypsum microprisms (80X), dump of Strawbridge Copper prospect 2. Photograph by T. W. Myers.
11. Kasolite (golden yellow) microcrystalline crust on reduced sandstone, Rock Run uranium occurrence (WPMM m4841).
12. Kasolite (60X), close-up of specimen shown in photograph 11, Rock Run uranium occurrence (WPMM m4841). Photograph by T. W. Myers.
13. Linarite-like unknown (deep blue) and anglesite (cream) around carbonaceous plant trace, 6 m (20 ft) northwest of the southeast adit, McCauley prospect 22 (WPMM m5415).
14. Malachite as acicular microcrystals (80X), McCauley prospect 28–1/2 of Mahar (WPMM m5401). Photograph by T. W. Myers.
15. Malachite (green) as concentric overgrowths on chrysocolla (bluish green), Rock Run Church copper prospect (WPMM 5402).



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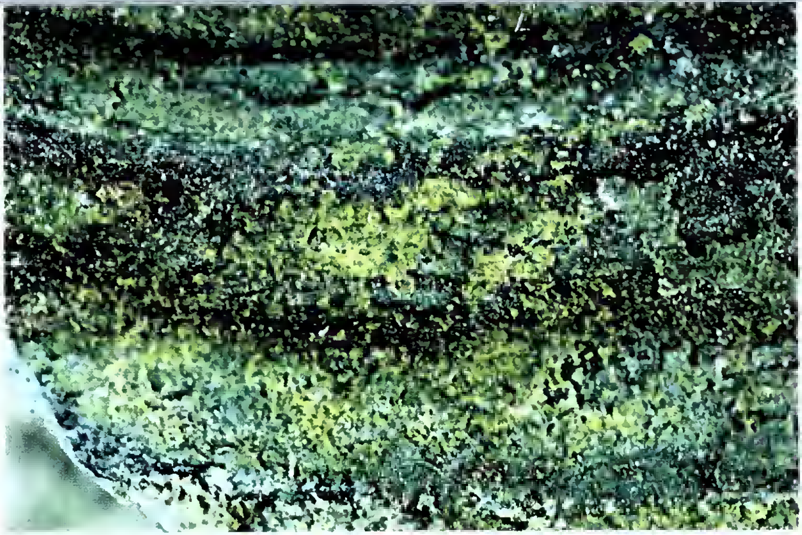

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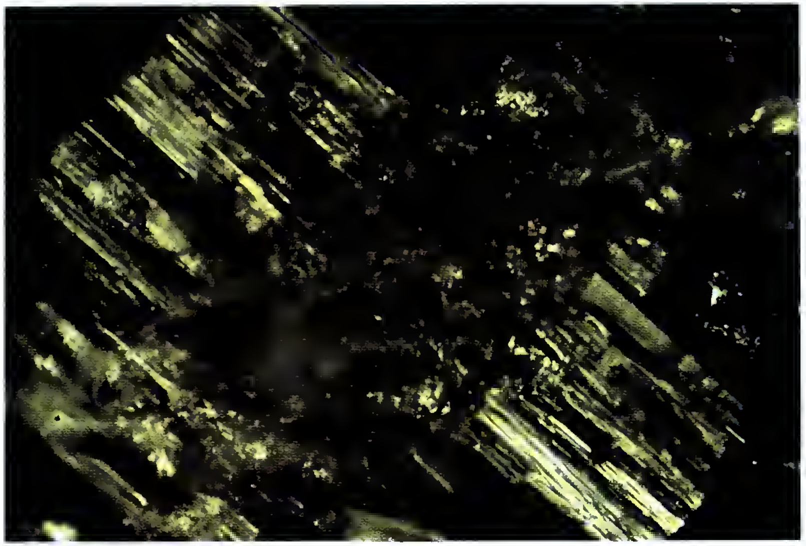

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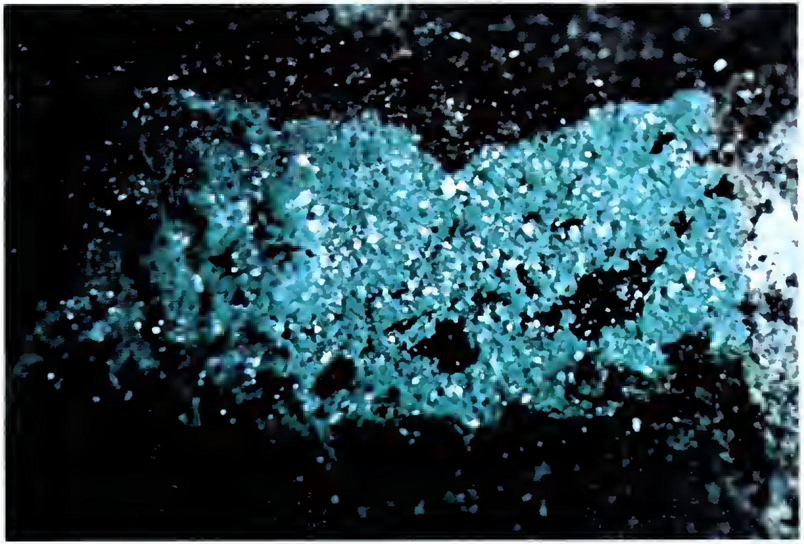

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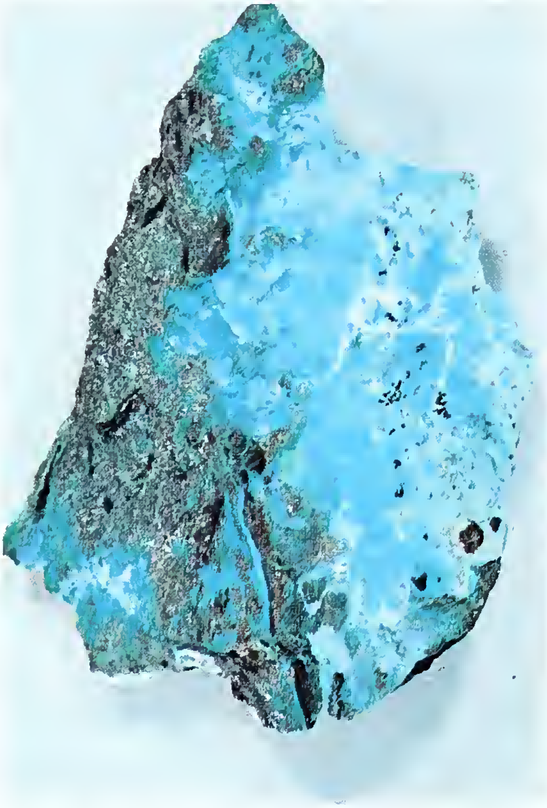

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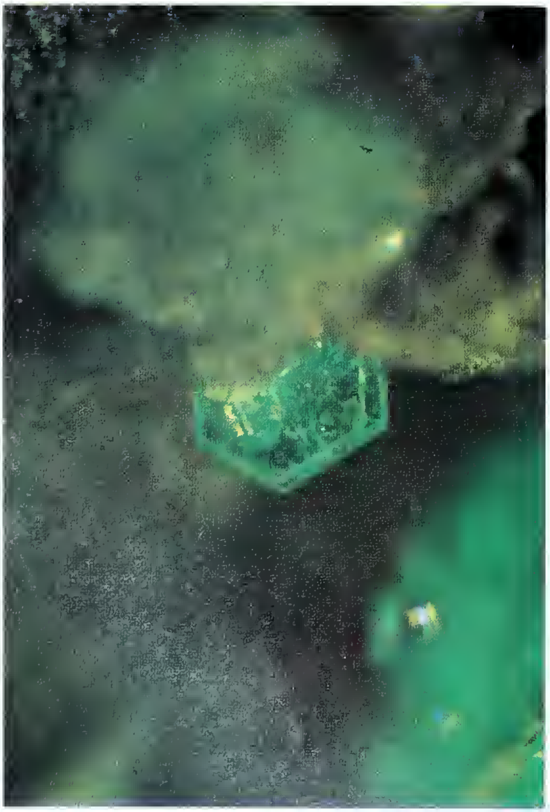

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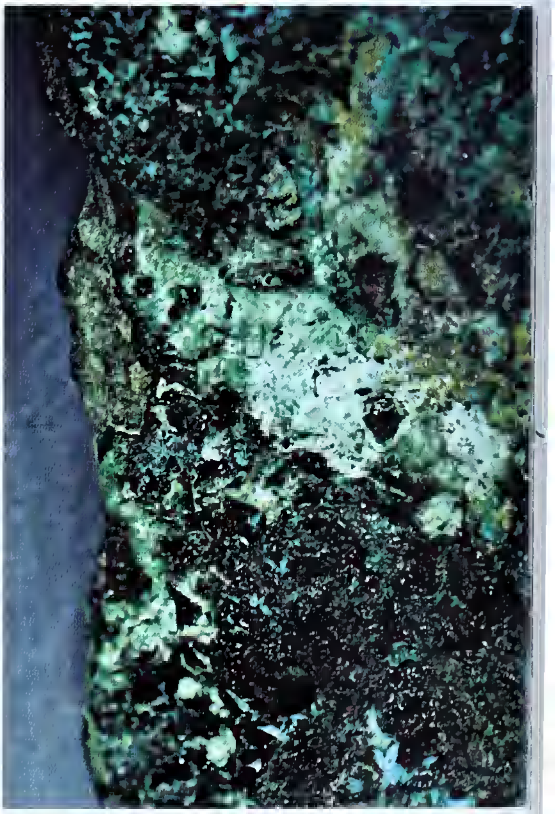

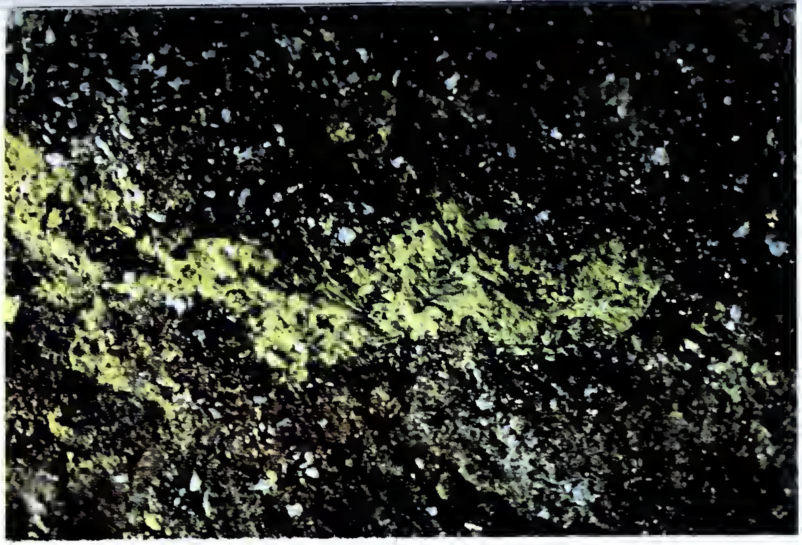
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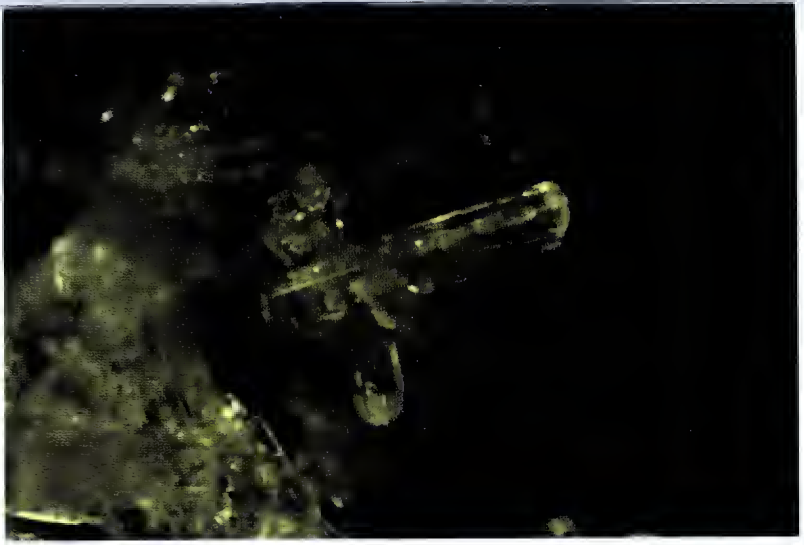
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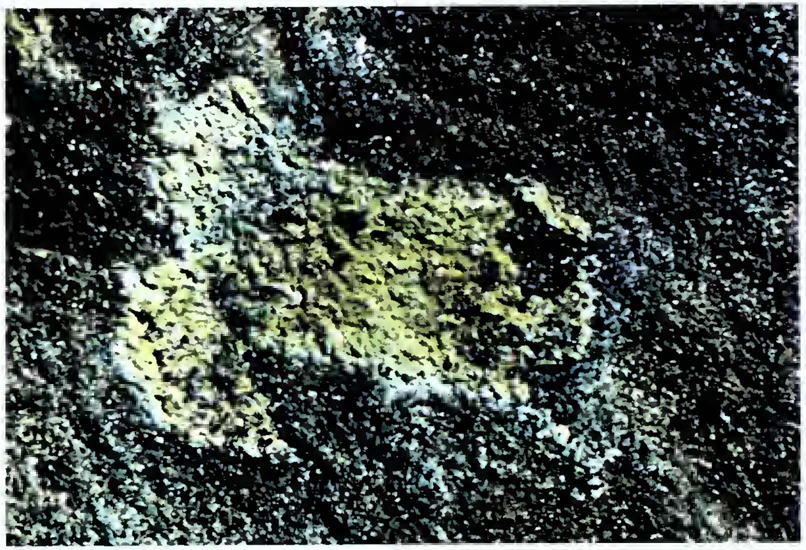
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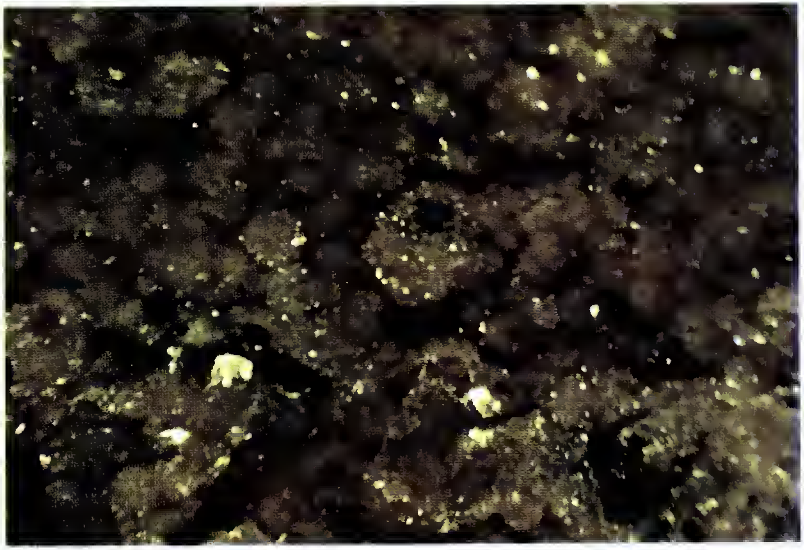
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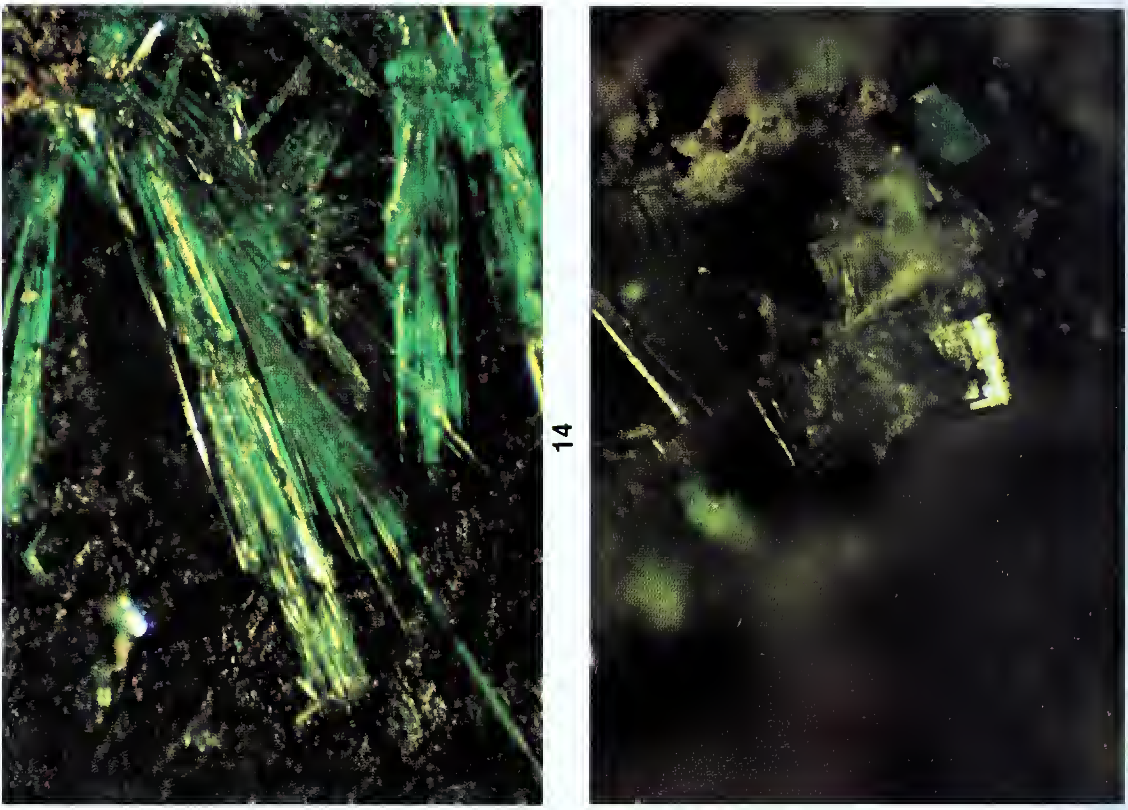

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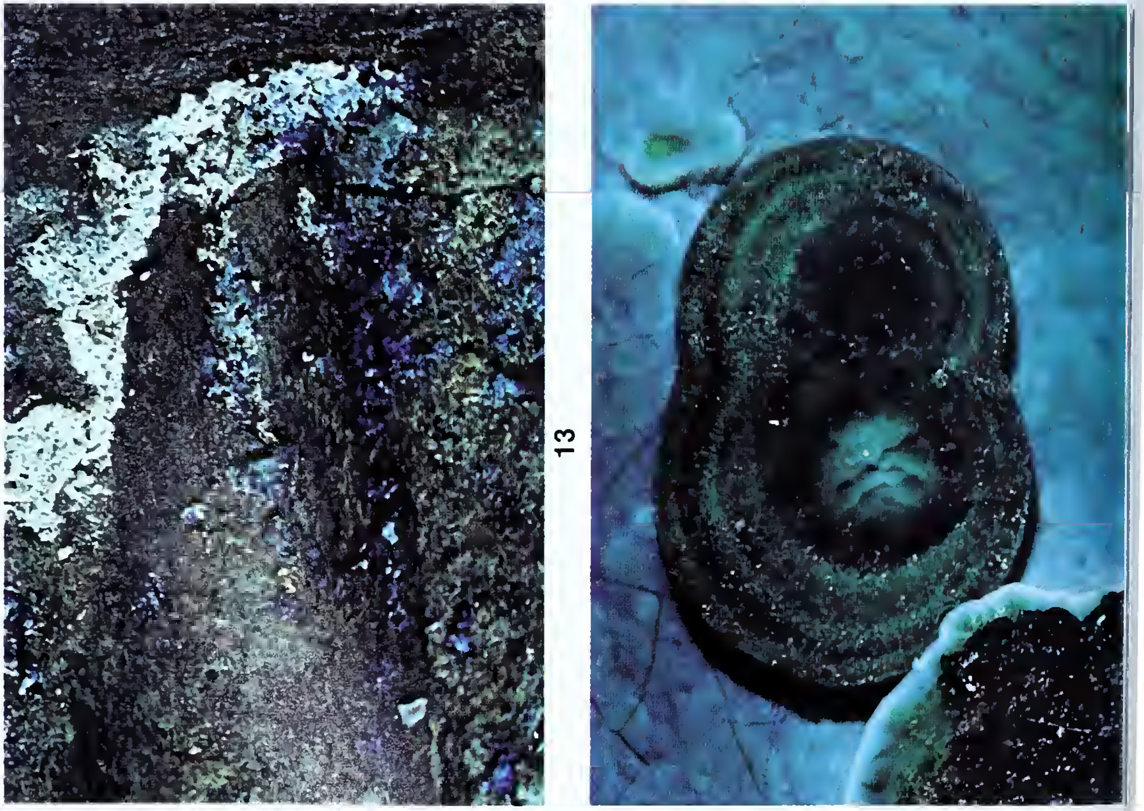

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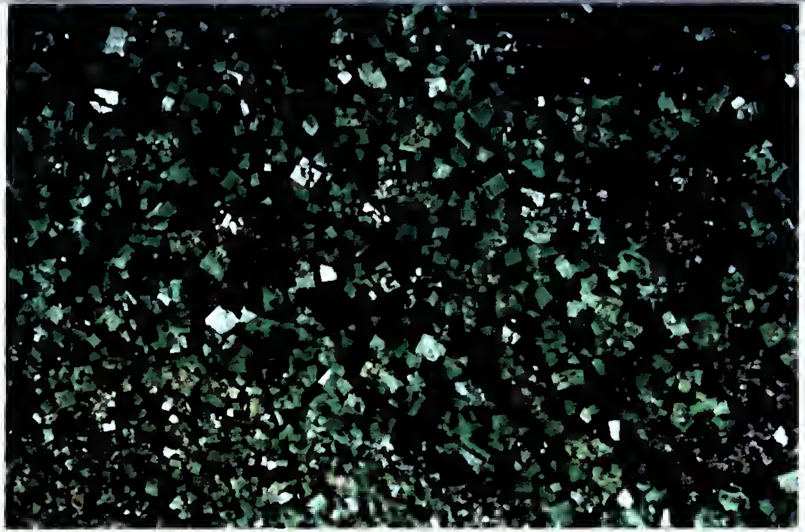

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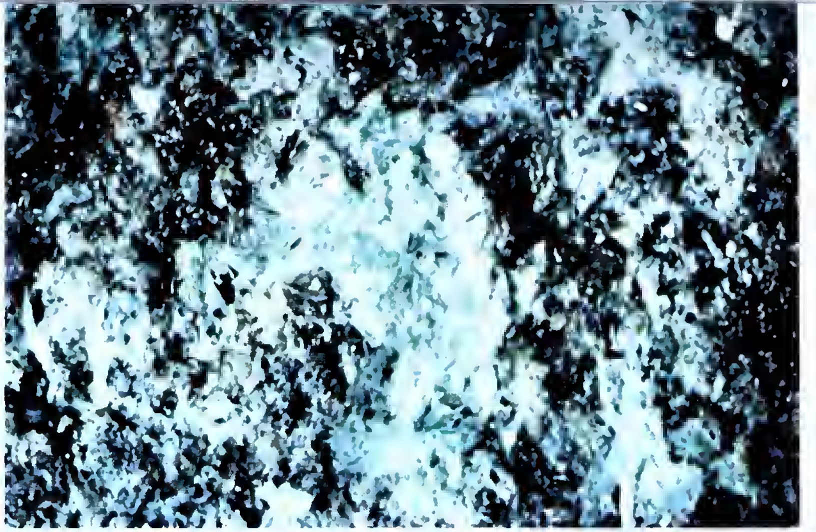

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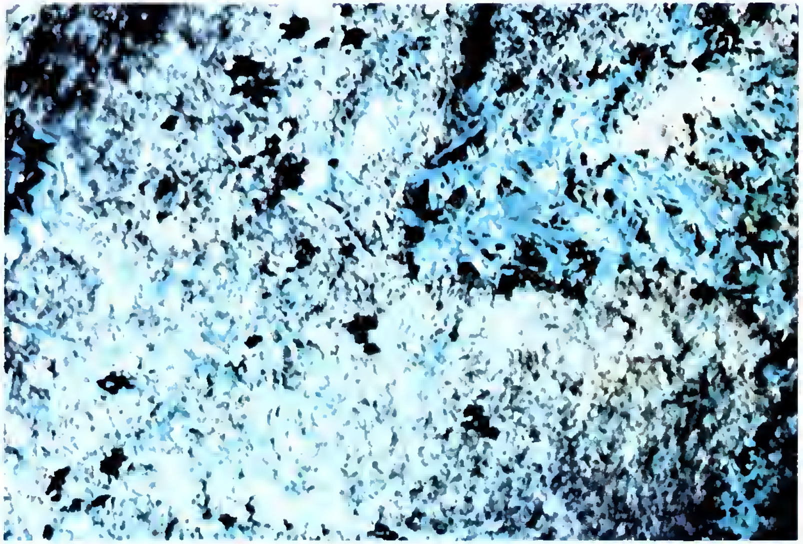

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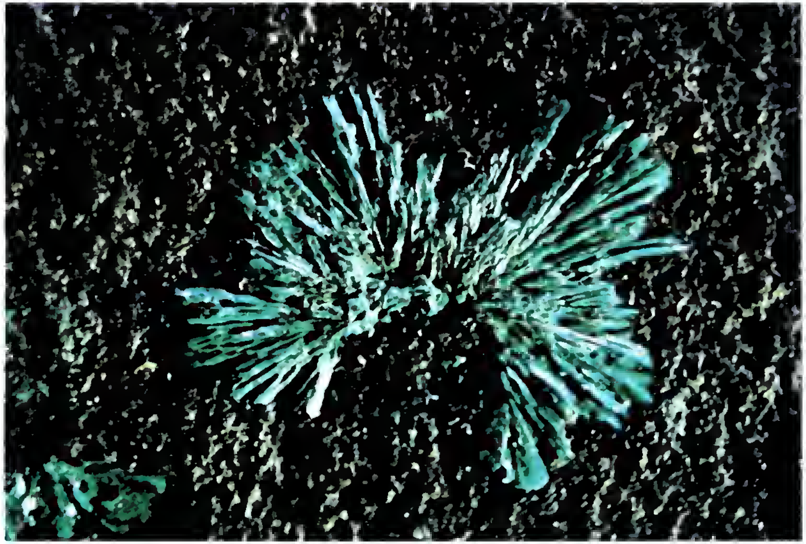

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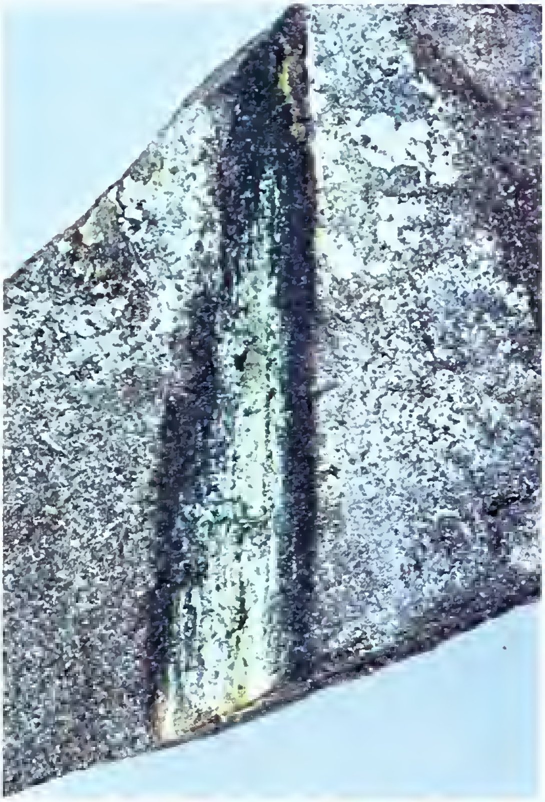

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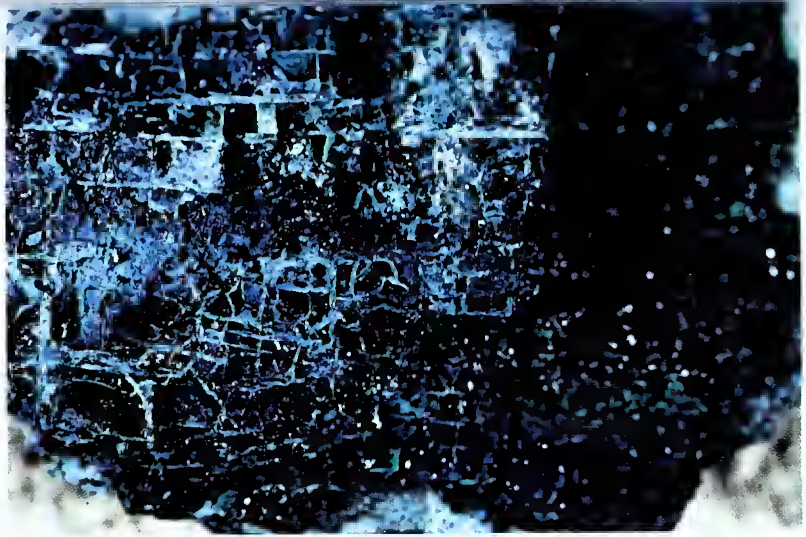

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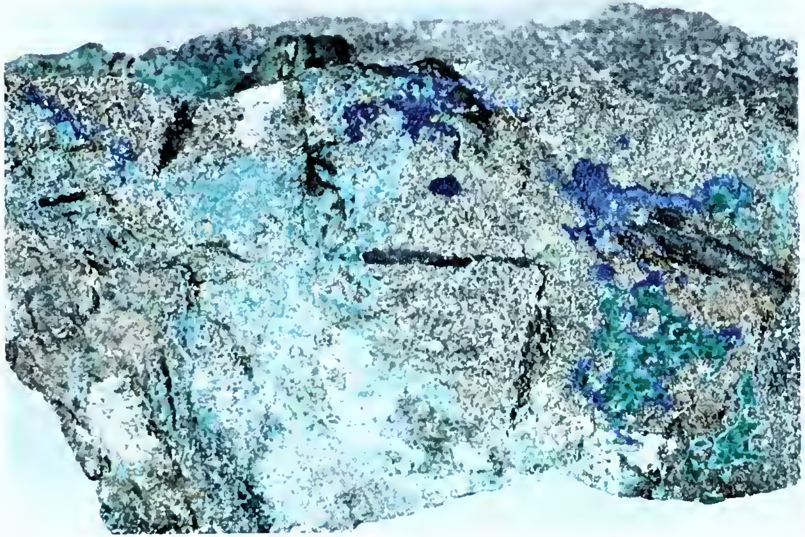

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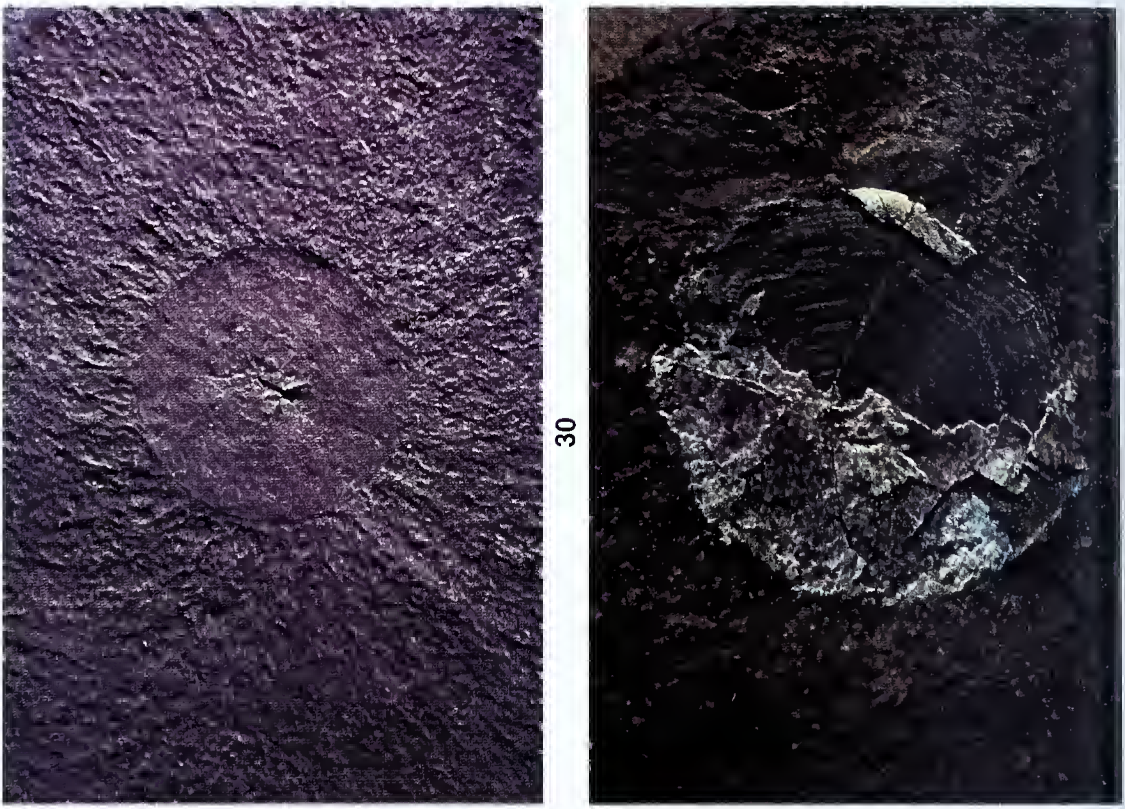

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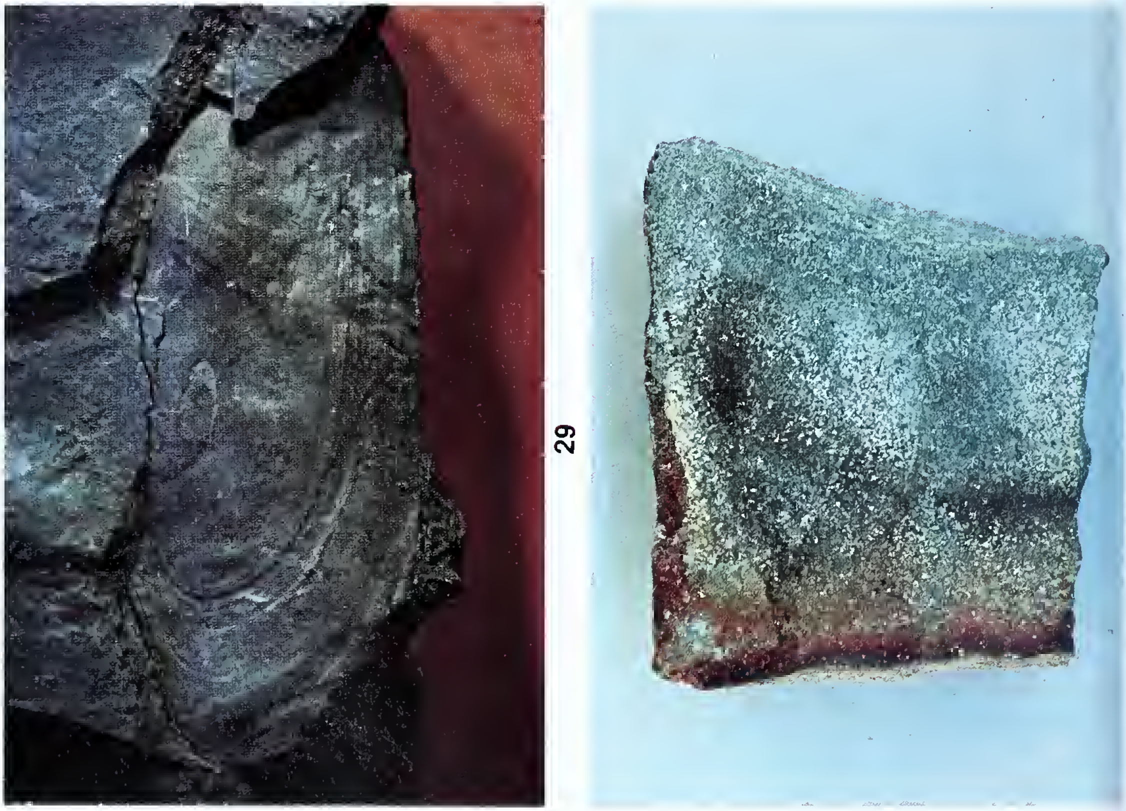


29

Photograph

16. Metazeunerite or metatorbernite rectangular microcrystals (100X), southeast adit, Copper Hollow 8 prospect (WPMM m5403). Photograph by T. W. Myers.
17. Metazeunerite as millimeter-sized tetragonal prisms, McCauley prospect 17.
18. Olivenite as pale-green, fibrous crusts on reduced sandstone, southeast adit, McCauley prospect 22 (WPMM m4905).
19. Posnjakite as acicular microcrystals on reduced sandstone, McCauley prospect 18.
20. Tyrolite as radiated micaceous blades on reduced sandstone, McCauley prospect 17.
21. Tyuyamunite as microcrystalline crust on "limonite"-stained reduced sandstone, 80-m site, Sonestown Nose uranium trench of Gill-Jordan.
22. Uraninite (black) as a replacement of a carbonaceous twig with uranophane, southeast adit, Copper Hollow 8 prospect (WPMM m4804).
23. Uranophane (pale yellow), malachite (green), and minor brochantite (green), Old Farm uranium-copper occurrence (WPMM m5404).
24. Widenmannite (dull yellow) on "limonite"-stained reduced sandstone, 80-m site, Sonestown Nose uranium trench of Gill-Jordan.
25. Azurite (blue) and malachite (green) within and between shrinkage cracks in a carbonaceous plant fragment, Jordan borrow pit (WPMM m5400).
26. Beudantite (yellow) in shrinkage cracks in a carbonaceous plant fragment, 15 m (50 ft) N88°W of McCauley prospect 17.
27. Malachite (green) and azurite (blue) on a bedding parting in reduced sandstone containing carbonaceous plant fragments, north side of adit entrance, McCauley prospect 24 (WPMM E146). Collected by J. H. Way, Jr.
28. Tyuyamunite (yellow) filling shrinkage cracks in carbonaceous plant fragments, 80-m site, Sonestown Nose uranium trench of Gill-Jordan.
29. *Archanodon* (4 by 12 cm, or 1.6 by 4.7 in.) in reduced sandstone, Hamilton-Jordan copper-uranium prospect.
30. Fossil algae colony(?) (0.9 cm, or 0.35 in.), in oxidized shale, Rock Run Church copper prospect.
31. Moderate-reddish-brown (10R4/6) weathering rind on reduced sandstone containing trace disseminated chalcopyrite, Middle Catskill Reduced Zone uranium-copper occurrence.
32. Phosphatic (carbonate-fluorapatite?) fish scale, Jordan borrow pit (WPMM V110). Collected by W. D. Sevon.

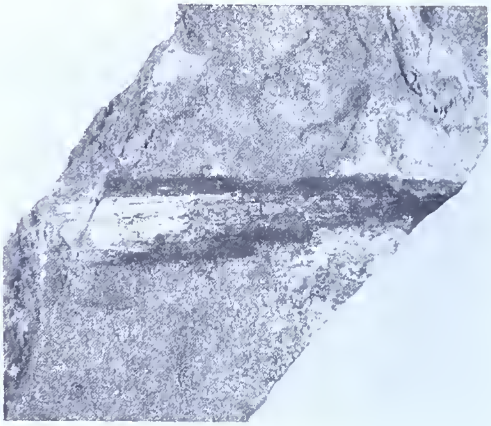


Figure 38. Uraninite as a dark replacement of a carbonaceous plant fragment enclosing an area oxidized to uranophane, from the caved southeast adit of Copper Hollow 8 prospect.

curring near the uraninite; chrysocolla as olive-green, blue-green, and blue crusts closely associated with malachite; brochantite as emerald-green crystalline crusts and microcrystals on the copper sulfides, including one rich ''chalcocite'' fossil-limb replacement from 6 m (20 ft) northeast of the caved adit's center; azurite as rare microbotryoidal crusts and groups of microcrystals associated with malachite; langite(?) and posnjakite(?) as microcrystals in and near the copper sulfides; chalcophyllite as rare bluish-green, pseudohexagonal microcrystals; rare tyrolite as blue-green, bladelike microlaminae, usually radiated; olivenite(?) as a rare light-gray-brown coating associated with brochantite; barite as rare colorless to white, tabular microcrystals and a crystalline crust on a plant-fossil mold; and quartz as microcrystals, some doubly terminated, in and near ''chalcocite'' as partial replacements of a carbonaceous plant fragment.

4. GEOLOGIC DESCRIPTION: The prospect consists of a pair of short adits along a ledge which trends approximately N75°W. There is a distance of 8.8 m (29 ft) from the center of the northwest adit to the center of the southeast (caved) adit, and there is some evidence of nearly continuous prospecting work under the overhang between the two adits.

The northwest adit (Figure 39) trends N30°E, is 7.9 m (26 ft) long (from the ledge overhang to the rear), has an average height of approximately 2 m (7 ft), and is 1.4 m (4.6 ft) wide at the rear. A joint on the northwest side of this adit trends N35°E and dips 87°SE. The roof of the adit is the bottom surface of a channel scour which has moderate relief. The thickness of the reduced zone in the back of the northwest adit is approximately 110 cm (43 in.). Drill holes that appear to be of different periods of origin are present in the back of the adit. A channel sample and stratigraphic description (Table 31) were obtained 4.9 m (16 ft) southeast of the center of the northwest adit.

The southeast adit (Figure 40) is now caved in, but observations made by Hoff in about 1957 while collecting a uraninite twig replacement suggest that it was not appreciably more extensive than the presently visible, collapsed roof monolith. The width of the adit was 2.3 m (7.5 ft), the sides being defined by two well-developed vertical joints which trend

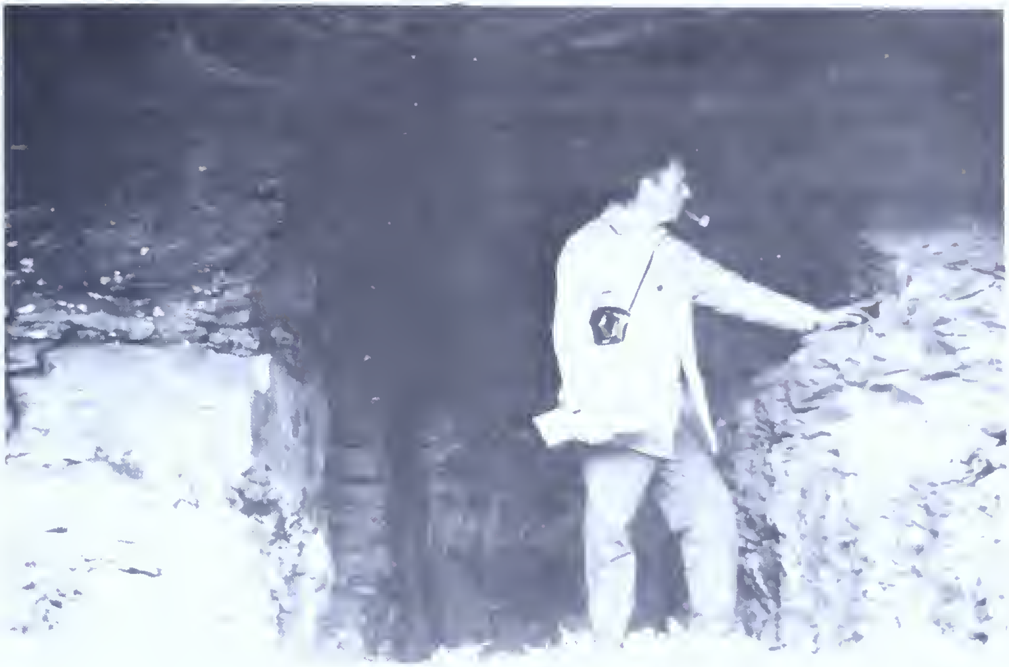


Figure 39. View into the northwest adit of Copper Hollow 8 prospect, 1.18 km (0.73 mi) southwest of the outlet of Beaver Lake.

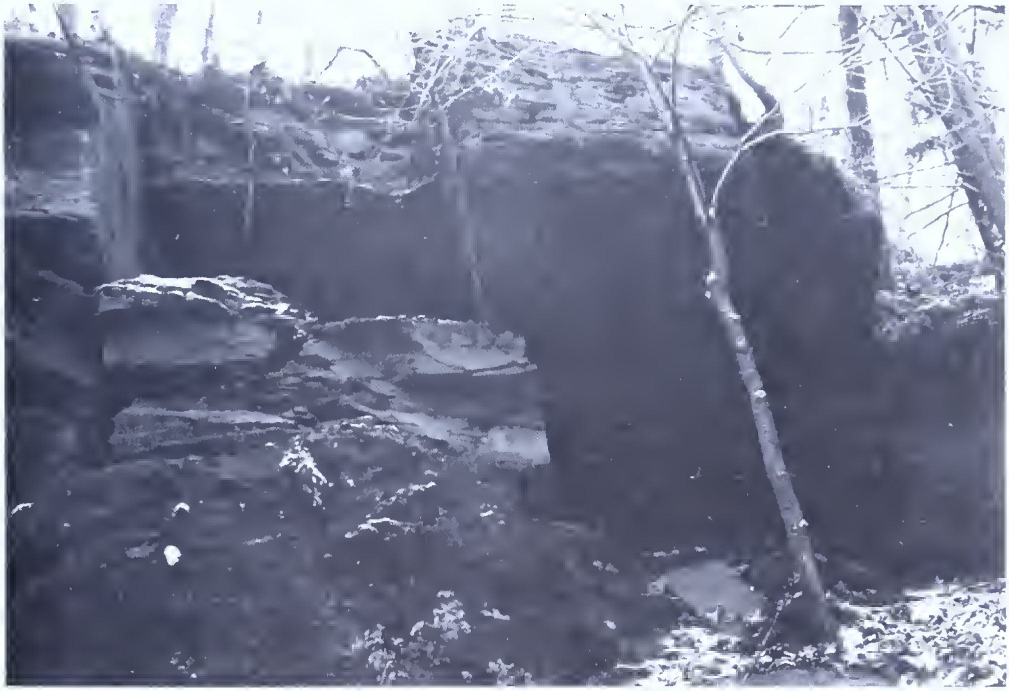


Figure 40. View of the southeast adit of Copper Hollow 8 prospect, 1.18 km (0.73 mi) southwest of the outlet of Beaver Lake. The large monolith blocking the entrance fell between visits by D. T. Hoff in 1958 and 1978.

Table 31. *Stratigraphic Section of Catskill Formation Rocks at Copper Hollow 8 Prospect*

Exposure is a prospected outcrop 4.9 m (16 ft) southeast of the center of the northwest adit.

Thickness (cm)	Radioactivity ("mR/hr")	Lithologic description
>100	.025	Grayish-red (5R4/2) and between grayish red (5R4/2) and grayish red purple (5RP4/2). Fine-grained, micaceous, thin-bedded sandstone. The contact of this unit with the lower unit shows moderate relief.
51	.08	Dark-greenish-gray (5G4/1) to medium-dark-gray (N4), micaceous, laminated to thin-bedded, crossbedded siltstone and fine-grained sandstone, which is grayish red (10R4/2) near the top. The unit contains grayish-red (5R4/2) laminae which contain uraninite as fossil twig replacements in the caved adit and approximately 2 m northwest of the center of the caved adit. The unit contains copper sulfide replacements of carbonaceous limbs which have abundant associated secondary malachite. The 51-cm-thick assayed siltstone and fine-grained sandstone sample was taken from this unit.
44	.065	Between medium gray (N5) and medium dark gray (N4). Medium-grained, thin- to medium-bedded sandstone.
3	.04	Between greenish gray (5G6/1) and dark greenish gray (5G4/1). Calcareous breccia.
>300	.03	Grayish-red (5R4/2) interbedded shale, mudstone, siltstone, and fine-grained sandstone.

N32°E and N35°E. A "chalcocite" replacement of a limb was collected 6.0 m (20 ft) southeast of the center of the caved adit, and uranium mineralization was traced an additional 6 m (20 ft) southeast along the outcrop.

Bedding in the area of the two adits trends approximately N75°W and dips 6°N. The long axes of replaced limbs in the prospect area trend N75°E, N80°E, and N90°E.

Because of the large number of copper-uranium occurrences at approximately this horizon (Plates 1 and 4), further study of the area may be warranted.

Hamilton-Jordan Copper-Uranium Prospect

1. LOCATION:
   (a) The prospect is located on the southwest edge of a trail which trends S40°E from the Beaver Lake-Ebenezer Church road, 1.53 km (0.95 mi) southwest of the outlet of Beaver Lake, Penn Township, Lycoming County. The prospect is about 82 m (269 ft) southeast along the trail and 6.5 ± 1 m (21 ± 3 ft) higher than the center of the Beaver Lake-Ebenezer Church road (Plate 1). The trail leaves this road 59 m (194 ft) northwest of the northwest end of Hess Hill Road. From

the intersection of the Beaver Lake-Ebenezer Church road with Loop Road at 1,203 feet (367 m), it is 0.55 km (0.34 mi) southeast to the prospect.

(b) Latitude: 41°17′10″N
Longitude: 76°36′21″W

2. ASSAYS: An 87-cm (34-in.) channel sample of gray shale and siltstone contains 187 ppm U_3O_8 and 1,500 ppm copper. A cutoff of 0.1 "mR/hr" was used to define the mineralized zone. Radiometric assays over the center of the channel cut yielded 250 ppm eU and 1,050 cps gross count. See sample MHK 785, Appendix 3.
3. MINERALOGY:
   (a) Major: None.
   (b) Minor: "Limonite" in and/or near carbonaceous plant fragments.
   (c) Trace: In gray shale-siltstone—zeunerite-metazeunerite-metatorbernite(?) as square, emerald- to yellow-green, micaceous microcrystals in and/or near fossil plant fragments, some of which are carbonaceous; beudantite(?) as grayish-green, spongy masses in carbonaceous plant fragments; unidentified thin yellow-green desiccated crusts near weathered fossil plant fragments; quartz in cleats in carbonaceous plant fragments; fluorescent green (UV, short wave) stains; malachite in and/or near carbonaceous plant fragments; and "apatite" as phosphatic fish remains. In calcareous breccia—"apatite" as phosphatic fish remains.
4. GEOLOGIC DESCRIPTION: The occurrence was discovered by John Jordan while excavating a road for Mr. Hamilton. The prospect was de-

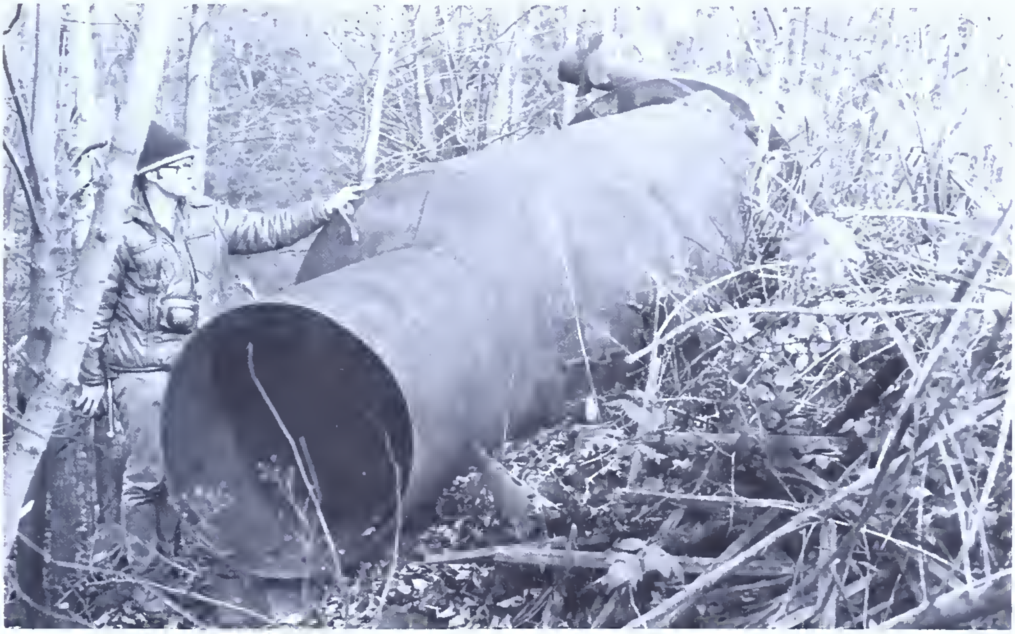


Figure 41. Oblique view of the copper smelter fabricated of steel for the Hamilton-Jordan copper-uranium prospect.

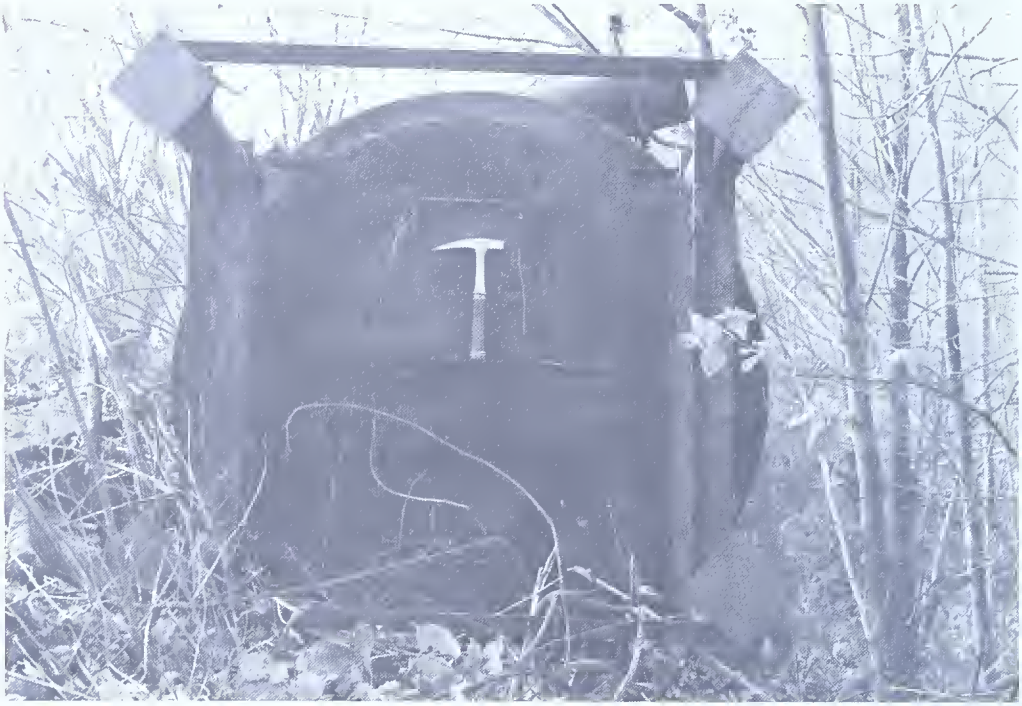


Figure 42. View of the base of the copper smelter for the Hamilton-Jordan copper-uranium prospect.

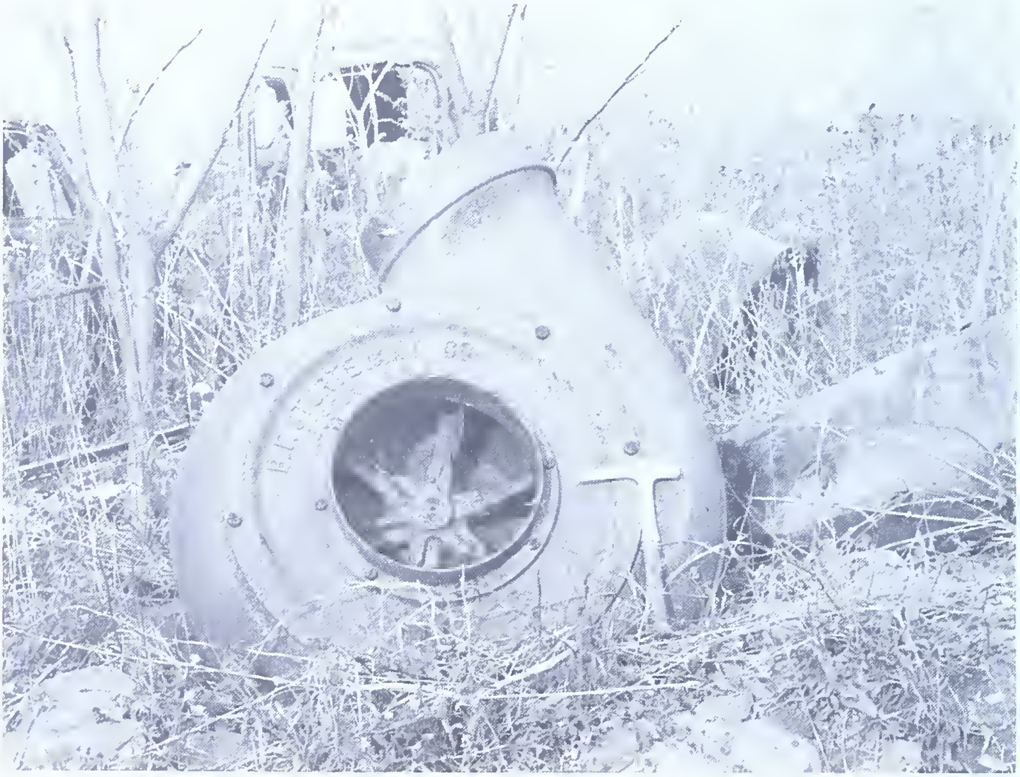


Figure 43. Fan believed to have been part of the copper smelter for the Hamilton-Jordan copper-uranium prospect.

veloped by Jordan and Hamilton, and the latter designed and fabricated a copper smelter (Figures 41 to 43). In view of the low grade observed for copper at this prospect, it is unlikely that any copper was actually smelted. The smelter is now located a short distance east of the old Jordan sawmill (41°18′39″N/76°35′12″W). The prospect consisted of two separate excavations along the trail (Figure 44). The southeast excavation is 3 m (10 ft) long in a northwest-southeast direction along the back, and the southeast corner was selected for the channel sample and stratigraphic description (Table 32). The northwest excavation is located about 10 m (33 ft) to the northwest (along the trail) and is now largely backfilled with brush and briers. A schematic sketch of the excavations is presented in Figure 44.

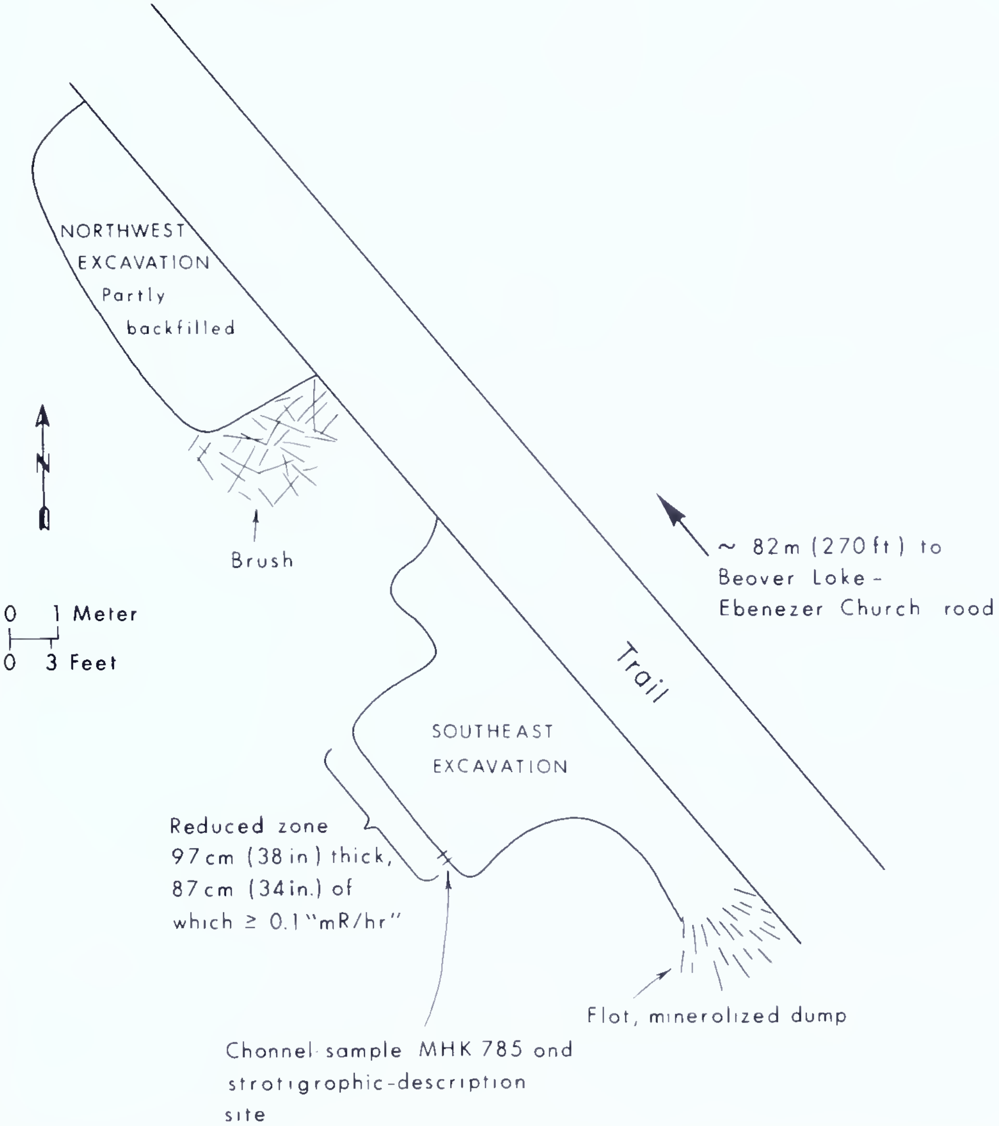

NORTHWEST EXCAVATION
Partly backfilled
N
Brush
0 1 Meter
0 3 Feet
~ 82m (270 ft) to Beaver Lake - Ebenezer Church road
Trail
SOUTHEAST EXCAVATION
Reduced zone 97 cm (38 in) thick, 87 cm (34 in.) of which ≥ 0.1 "mR/hr"
Flat, mineralized dump
Channel sample MHK 785 and stratigraphic-description site

Figure 44. Schematic plan map of the Hamilton-Jordan copper-uranium prospect, 1.5 km (0.93 mi) southwest of the outlet of Beaver Lake, Penn Township, Lycoming County.

Table 32. *Stratigraphic Section of Catskill Formation Rocks at the Hamilton-Jordan Copper-Uranium Prospect*

Exposure is in the southeast corner of the southeast excavation.

Thickness (cm)	Radioactivity ("mR/hr")	Lithologic description
>130	.03	Grayish-red (5R4/2), laminated to thin-bedded, interbedded siltstone and fine-grained sandstone with a few thin shale laminae. The unit is blackish red (5R2/2) near the bottom.
97	.20 1.0 max.	Dark-greenish-gray (5GY4/1), laminated to thin-bedded, interbedded shale and siltstone with minor fine-grained sandstone laminae. The unit is olive gray (5Y4/1) near the top and contains several grayish-red (10R4/2) laminae, and carbonaceous plant fragments accompanied by trace malachite. The 87-cm-thick assayed shale-siltstone sample was taken from this unit. The top 10 cm did not meet the 0.1-"mR/hr" cutoff used.
>10	.06	Between grayish red (5R4/2) and dusky red (5R3/4). Thin-bedded mudstone; contains two thin beds of dark, punky calcareous breccia near the top, from which the calcite has weathered. Phosphatic fish remains are present in the calcareous breccia. Recorded radioactivity is probably high due to the geometry.

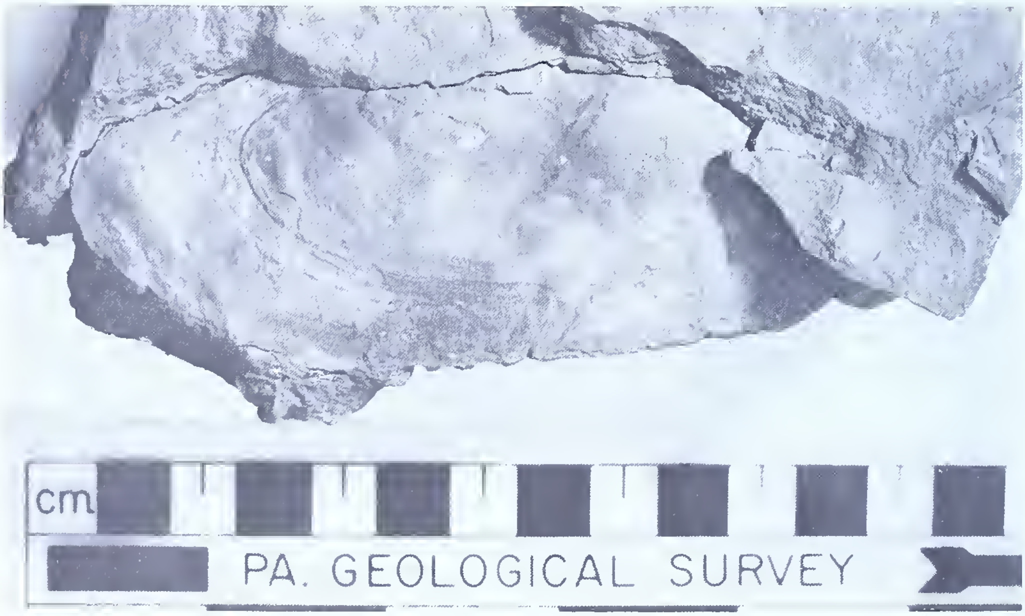


Figure 45. *Archanodon, a fossil freshwater clam, in gray siltstone, Hamilton-Jordan copper-uranium prospect. The clam is 11.9 cm (4.7 in.) long and 4.6 cm (1.8 in.) wide.*

Of the 97 cm (38 in.) of reduced, interbedded shale and siltstone in the southeast excavation, 87 cm (34 in.) had a radioactivity of $\geq$ 0.1 "mR/hr" and an average of 0.2 "mR/hr." A maximum of 1.0 "mR/hr" was observed on a "limonite"-stained plant fragment near the top of the channel cut. Compared to most gray shale-siltstone occurrences in the district, this is a moderately thick zone to have as much as 187 ppm U_3O_8. The presence of trace, but visible, secondary uranium minerals in such a rock is also surprising. The exposed length of the zone yielding $\geq$ 200 cps with the scintillometer is 20 m (66 ft).

The discovery of a 4.5- by 12-cm (1.8- by 4.7-in.) fossil *Archanodon* (Figure 45 and color photograph 29) on the dump suggests that the depositional environment was nonmarine, i.e., freshwater, based on modern equivalents (T. M. Berg, personal communication, 1979). Phosphatic fish remains occur in the exposed gray siltstone and underlying weathered calcareous breccia.

Considering the apparent shallow north dip of bedding in this area, the mineralized horizon corresponds well to that in Copper Hollow. Further examination may be warranted.

Jordan Sawmill Adits

1. LOCATION:
   (a) The southwest (main) and northeast adits are located on the John Jordan property downstream from a falls (Figure 46) on a small, west-flowing tributary to the feeder stream at the north end of Beaver Lake. The southwest-adit roof entrance (Figure 47) is 1.7 m (5.6 ft) above the tributary's water level, 12 m (39 ft) south of its center, and 200 ± 15 m (650 ± 50 ft) east of the site of John Jordan's old sawmill. The northeast-adit entrance is 25.5 m (84 ft) N62°E of the southwest-adit entrance. The adits are 1.24 km (0.77 mi) southwest of Hemlock Grove and 1.97 km (1.22 mi) north-northeast of the outlet of Beaver Lake, Davidson Township, Sullivan County.

	Southwest adit	Northeast adit
(b) Latitude:	41°18′40″N	41°18′40″N
Longitude:	76°35′06″W	76°35′05″W

2. ASSAYS: A 95-cm (37-in.) channel sample of gray shale and siltstone containing scattered malachite, especially near the bottom half, has 39 ppm U_3O_8 and 3,000 ppm copper. See sample MHK 779, Appendix 3.
3. MINERALOGY:
   Southwest (main) adit
   (a) Major: None.
   (b) Minor: Malachite near and/or in, and as replacements of, fossil plant fragments, and as crusts on bedding partings.
   (c) Trace: Chrysocolla as friable, desiccated coatings; "apatite" as phosphatic fish remains; "limonite"; and quartz as doubly terminated, microcrystalline partial replacements of phosphatic fish remains and as fossae fillings.
4. GEOLOGIC DESCRIPTION: The southwest (main) adit is 6.5 m (21.3 ft) long and trends approximately S30°E. Near the southeast end, there

Figure 46. Falls on the tributary to Beaver Lake immediately upstream from Jordan Sawmill adits.

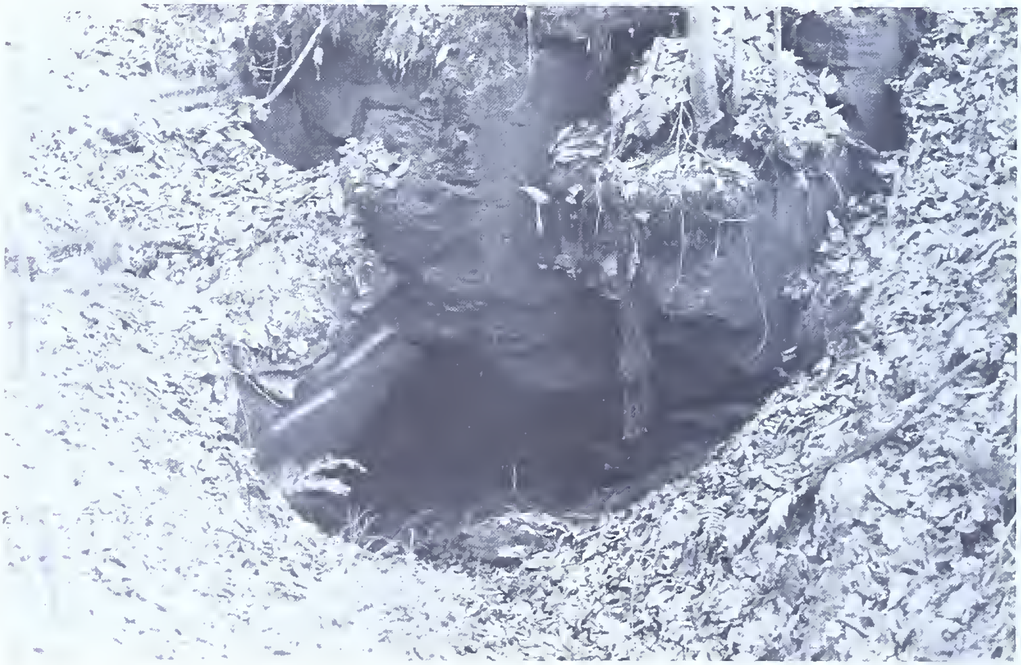


Figure 47. Entrance to the southwest adit of Jordan Sawmill adits. The hammer is in oxidized roof rock.

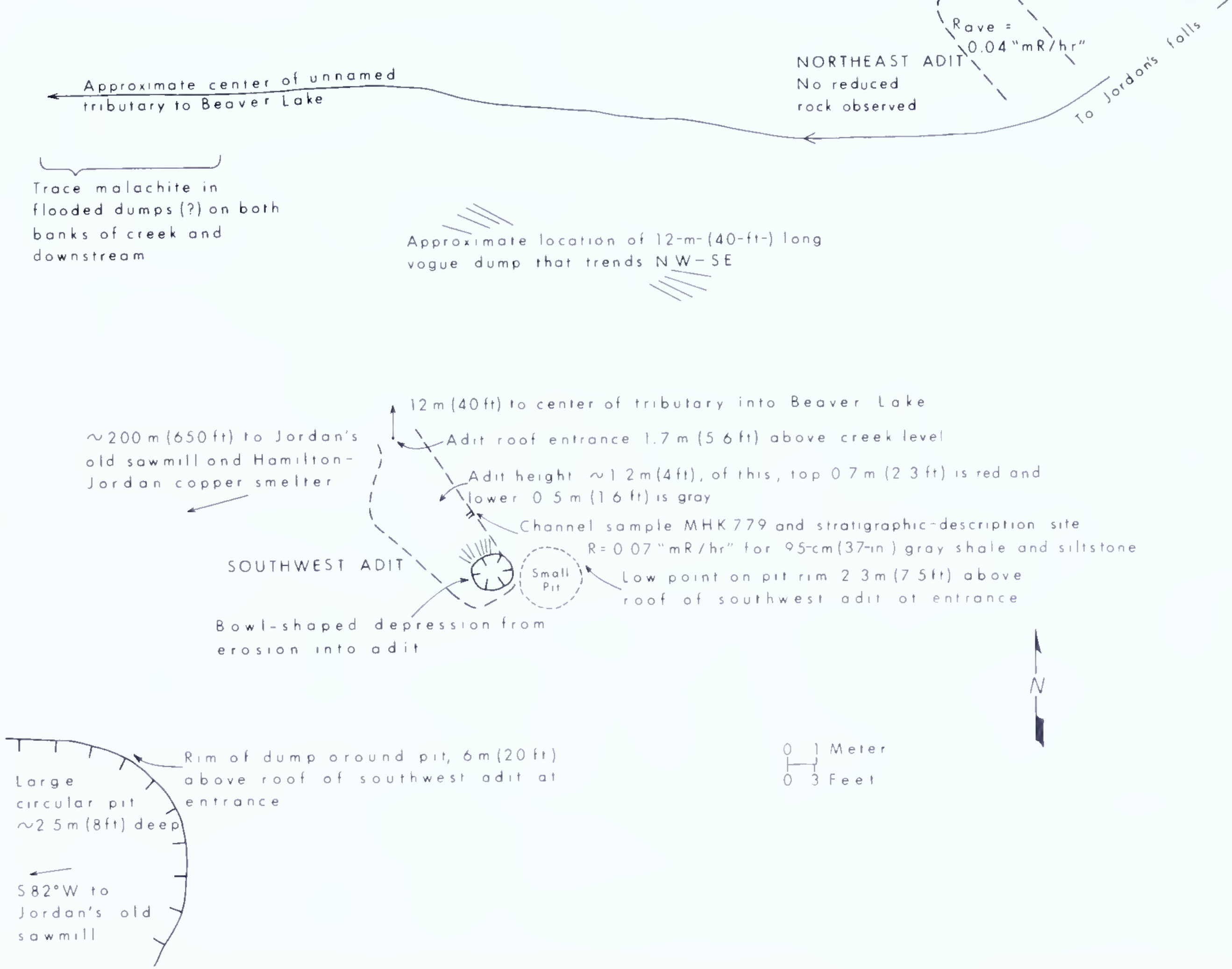

Rave =
0.04 "mR/hr"
NORTHEAST ADIT
No reduced
rock observed
To Jordon's falls
Approximate center of unnamed
tributary to Beaver Lake
Trace malachite in
flooded dumps (?) on both
banks of creek and
downstream
Approximate location of 12-m-(40-ft-) long
vogue dump that trends NW-SE
12 m (40 ft) to center of tributary into Beaver Lake
~200 m (650 ft) to Jordan's
old sawmill and Hamilton-
Jordan copper smelter
Adit roof entrance 1.7 m (5 6 ft) above creek level
Adit height ~1 2 m (4 ft), of this, top 0 7 m (2 3 ft) is red and
lower 0 5 m (1 6 ft) is gray
Channel sample MHK 779 and stratigraphic-description site
R = 0 07 "mR/hr" for 95-cm (37-in) gray shale and siltstone
SOUTHWEST ADIT
Small
Pit
Low point on pit rim 2 3 m (7 5 ft) above
roof of southwest adit at entrance
Bowl-shaped depression from
erosion into adit
N
Rim of dump around pit, 6 m (20 ft)
above roof of southwest adit at
entrance
Large
circular pit
~2 5 m (8 ft) deep
S82°W to
Jordan's old
sawmill
0 1 Meter
0 3 Feet

Figure 48. Schematic plan map of the Jordan Sawmill adits area, 1.97 km (1.22 mi) north-northeast of the outlet of Beaver Lake, Davidson Township, Sullivan County.

is a pile of debris that has apparently washed in from the surface. A small, bowl-shaped depression occurs on the surface directly above this area of apparent collapse. The adit appears to have been about 1.7 m (5.6 ft) high when originally dug during the nineteenth(?) century. Of this height, the top 0.78 m (2.6 ft) is in red mudstone-siltstone and the lower 0.95 m (3.1 ft) is in gray siltstone and shale. The roof rock is red sandstone. Based on excavation for the reduced, 95-cm (37-in.) vertical channel sample taken in the northeast wall 3.4 m (11 ft) southeast of the entrance, the copper-bearing zone is below the level of the present, debris-covered floor of the adit. The stratigraphy is described in Table 33.

Table 33. *Stratigraphic Section of Catskill Formation Rocks at Jordan Sawmill Adits*

Exposure (A) is above the roof at the entrance to the southwest adit; exposure (B) is on the northeast wall, 3.4 m (11 ft) from the entrance to the southwest adit.

	Thickness (cm)	Radioactivity ("mR/hr")	Lithologic description
(A)	>100	.03	Grayish-red (5R4/2), fine-grained, micaceous, thin- to medium-bedded sandstone. In the adit, there is approximately 40 cm of maximum relief on the contact of this unit with the underlying unit, due to cutouts.
(B)	78	.03	Grayish-red (5R4/2) interbedded mudstone and siltstone which breaks into small fragments upon exposure.
	≥ 95	.07	Between medium gray (N5) and dark greenish gray (5G4/1). Interbedded shale and siltstone which breaks into small fragments upon exposure. This assayed unit contains malachite and sparse small carbonaceous plant fragments throughout; large carbonaceous plant fragments and moderate amounts of malachite and chrysocolla are present near the bottom.

This location was furnished to A. T. Smith (1980), and his grab sample was collected 35 cm (14 in.) below the oxidized zone and 15 cm (6 in.) southeast of the assay site of the present study (Figure 48). The contact between oxidized and reduced rocks in the adit appears to dip gently toward the creek, i.e., northwest. A vertical joint in the adit trends N36°E.

The northeast, barren adit is 4.6 m (15 ft) long and excavated in red siltstone (top half) and mudstone (lower half). The background in the adit is only 0.04 "mR/hr" and the maximum is 0.06 "mR/hr." No reduced rock or copper mineralization was observed at this adit.

Klemic Locality 8
(Beaver Lake Copper Adit)

1. LOCATION:
   (a) The adit is on the K. Carl (formerly L. Confer) property on the northeast shore of Beaver Lake, 1.03 km (0.64 mi) north of the out-

let and 100 m (330 ft) south of the Sullivan County line, Penn Township, Lycoming County. The adit entrance (Figures 49 to 51) is 10 m (33 ft) east of the lake's edge and about 70 m (230 ft) north of the westward point of the Beaver Lake shoreline (see Plate 1). The adit-entrance roof is approximately 5 m (16 ft) above the level of the lake.

(b) Latitude: 41°18′11″N
Longitude: 76°35′31″W

2. ASSAYS: A 65-cm (26-in.) channel sample of gray sandstone containing carbonaceous plant fragments and trace malachite has 11 ppm U_3O_8, 280 ppm copper, and about 0.33 percent lead. The lower 28-cm (11-in.) shale-siltstone unit, including 2 cm (0.8 in.) of calcareous breccia containing secondary copper mineralization, has 5 ppm U_3O_8 and 5,500 ppm (0.55 percent) copper. See samples MHK 739 and 738, Appendix 3.
3. MINERALOGY:
   (a) Major: None.
   (b) Minor: Chrysocolla, malachite, brochantite, langite and/or posnjakite microcrystals, and azurite (in order of decreasing abundance) in calcareous breccia; rare malachite and chrysocolla in reduced sandstone and siltstone.
   (c) Trace: In gray sandstone from roof of adit—opal (variety hyalite); barite as partial replacements of carbonaceous plant fragments and microcrystals; pyrite in chloritic replacements of carbonaceous plant fragments; and metatorbernite(?) microcrystals associated with the barite and also with the pyrite-chloritic replacements of carbon-

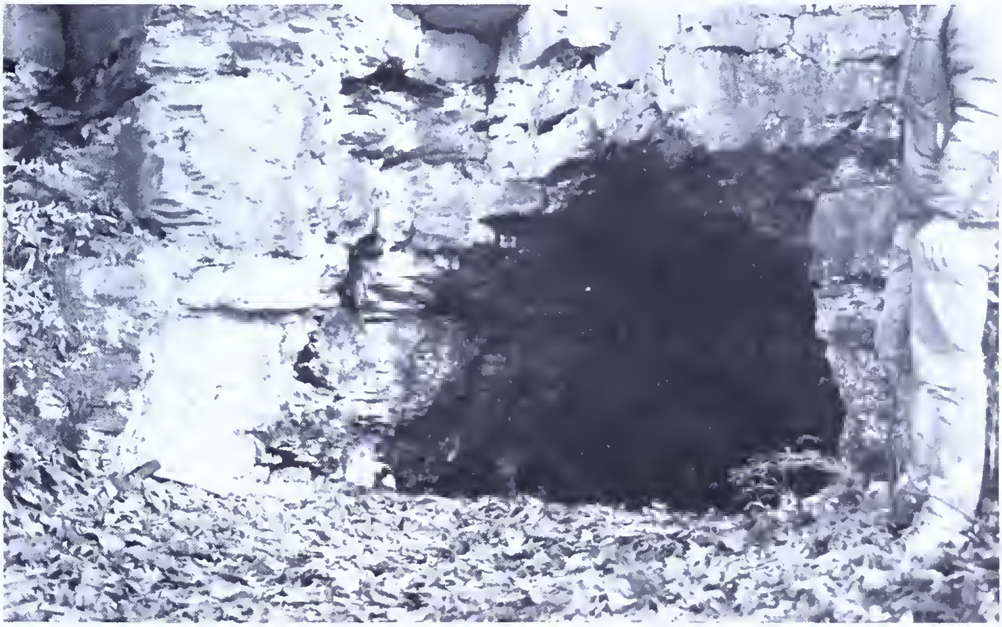


Figure 49. View of the entrance to Klemic locality 8 (Beaver Lake copper adit). Unlike many prospects in the area, the cross section is semicircular rather than rectangular.

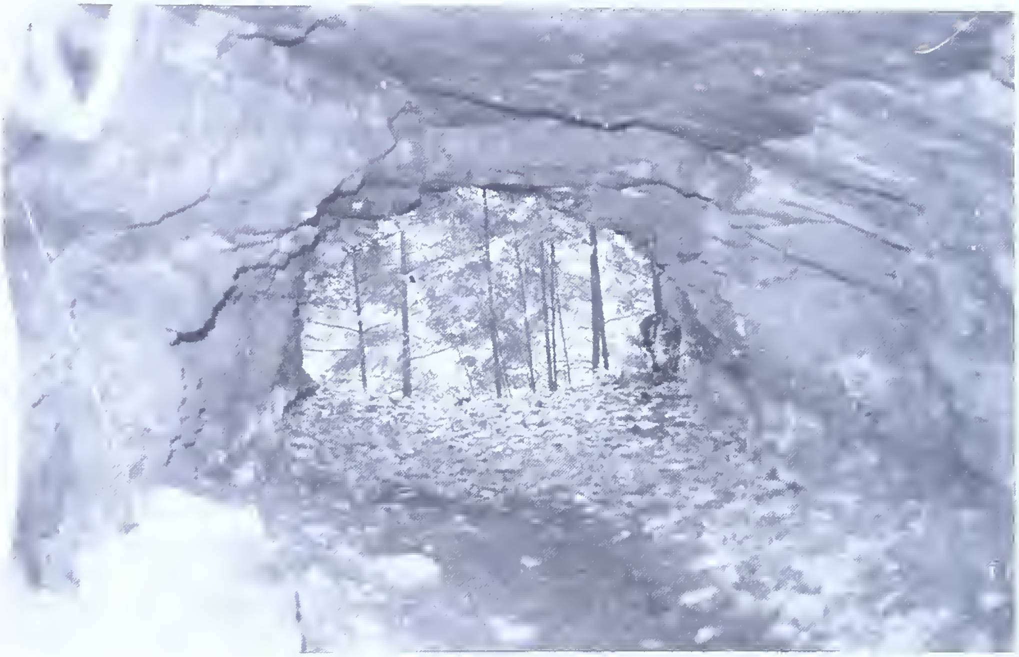
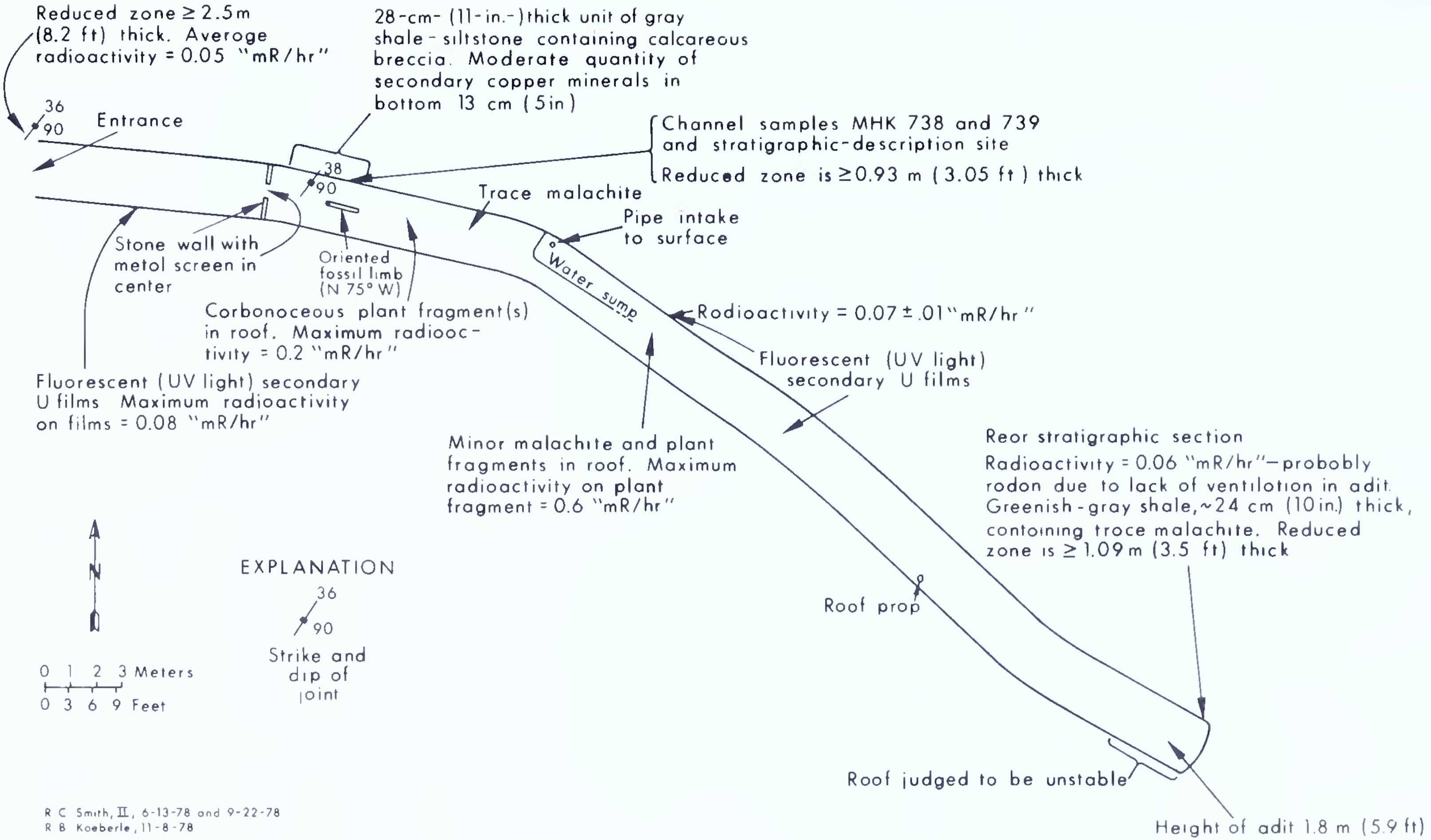


Figure 50. View looking out of Klemic locality 8 (Beaver Lake copper adit) from a stone-wall fence.

Figure 51. Carving of unknown age in medium-grained sandstone at the entrance to Klemic locality 8 (Beaver Lake copper adit).

aceous plant fragments. Weathered micrograins of bornite and ''chalcocite'' occur in the calcareous breccia.

4. GEOLOGIC DESCRIPTION: The Beaver Lake copper adit is 52.2 m (171 ft) long, is inclined a few degrees to the east, and trends east-southeast as shown in Figure 52. At the stone-wall fence the adit is 2.3 m (7.5 ft) wide and 1.4 m (4.6 ft) high, and at the rear it is 1.8 m (6 ft) wide and 1.8 m (6 ft) high. One roof prop (Figure 53) remains in place 12.6 m (41 ft) from the rear of the adit. The rear of the adit is judged unstable and



Reduced zone ≥ 2.5m (8.2 ft) thick. Averoge radioactivity = 0.05 "mR/hr"
36
90
Entrance
28-cm- (11-in.-) thick unit of gray shale - siltstone containing calcareous breccia. Moderate quantity of secondary copper minerals in bottom 13 cm (5in)
Channel samples MHK 738 and 739 and stratigraphic-description site
Reduced zone is ≥0.93 m (3.05 ft) thick
38
90
Trace malachite
Pipe intake to surface
Water sump
Stone wall with metol screen in center
Oriented fossil limb (N 75° W)
Corbonoceous plant fragment(s) in roof. Maximum radioactivity = 0.2 "mR/hr"
Rodioactivity = 0.07 ± .01 "mR/hr"
Fluorescent (UV light) secondary U films
Fluorescent (UV light) secondary U films Maximum radioactivity on films = 0.08 "mR/hr"
Minor malachite and plant fragments in roof. Maximum radioactivity on plant fragment = 0.6 "mR/hr"
Reor stratigraphic section
Radioactivity = 0.06 "mR/hr"—probobly rodon due to lack of ventilotion in adit. Greenish-gray shale, ~24 cm (10 in.) thick, contoining troce malachite. Reduced zone is ≥ 1.09 m (3.5 ft) thick
N
EXPLANATION
36
90
Strike and dip of joint
0 1 2 3 Meters
0 3 6 9 Feet
Roof prop
Roof judged to be unstable
Height of adit 1.8 m (5.9 ft)
R C Smith, II, 6-13-78 and 9-22-78
R B Koeberle, 11-8-78

Figure 52. Plan map of Klemic locality 8 (Beaver Lake copper adit), northeast shore of Beaver Lake, Penn Township, Lycoming County.

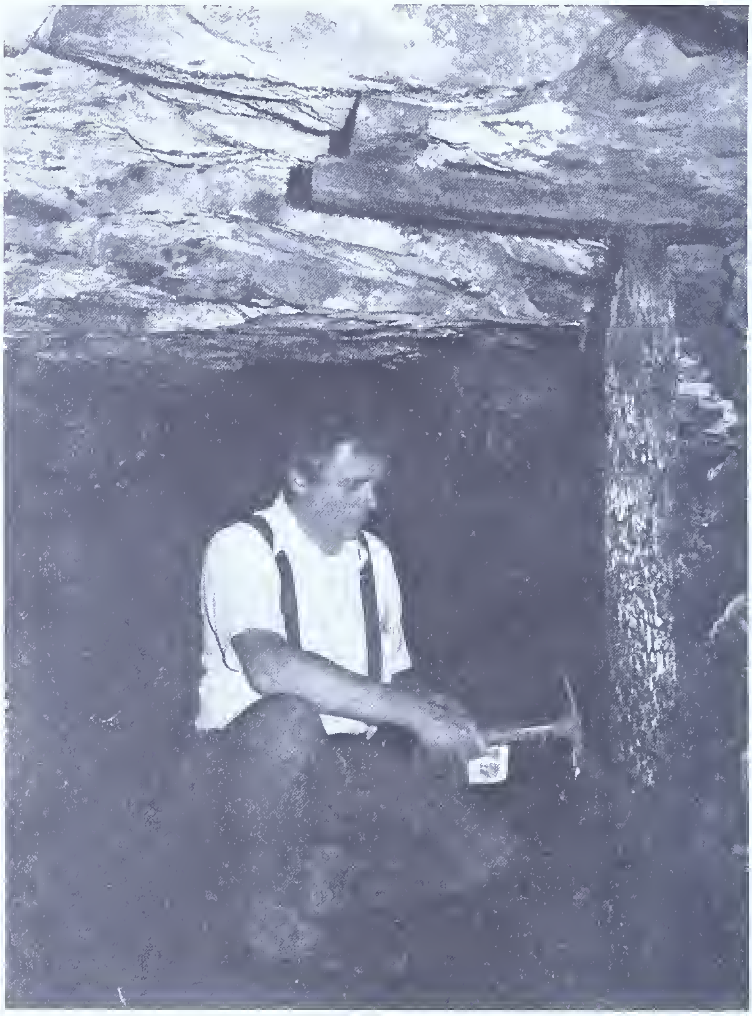


Figure 53. D. T. Hoff at a roof prop 12.6 m (41 ft) from the rear of Klemic locality 8 (Beaver Lake copper adit).

dangerous because of groundwater influx. This water collects on the north-northeast side of the adit and is pumped for cabin use from a trough which ends 32.5 m (107 ft) from the rear of the adit.

The stratigraphic section exposed at the channel-sample site, 39.6 m (130 ft) from the rear of the adit, is described in Table 34 and that in the rear of the adit is described in Table 35. The section exposed at the adit entrance consists of a 2.5-m- (8.2-ft-) thick upper unit of fine-grained, gray, crossbedded sandstone containing calcareous lenses and plant fragments, overlying a $\geq$ 0.3-m- (1-ft-) thick lower unit of oxidized mudstone. The persistence of the reduced, though very leanly mineralized, zone throughout the adit is notable and suggests a horizontal bedding attitude. Vertical jointing at the adit entrance trends N36°E, and 41 m (135 ft) from the rear it trends N38°E.

Table 34. *Stratigraphic Section of Catskill Formation Rocks 39.6 m (130 ft) from the Back of Klemic Locality 8 (Beaver Lake Copper Adit)*

Exposure is on the north side of the adit.

Thickness (cm)	Radioactivity ("mR/hr")	Lithologic description
≥ 65	.06	Olive-gray (5Y4/1), medium-grained, crossbedded, slightly micaceous sandstone. The unit contains large carbonaceous plant fragments, especially near the top, and trace malachite.
28	.06	Between dark greenish gray (5G4/1) and medium dark gray (N4). Interbedded shale and siltstone. Two centimeters of calcareous breccia occurs 11 cm from the bottom of the unit. Secondary copper minerals are abundant in the calcareous breccia.
> 84	.05	Grayish-red (10R4/2) interbedded mudstone, siltstone, and fine-grained sandstone.

Table 35. *Stratigraphic Section of Catskill Formation Rocks at the Back of Klemic Locality 8 (Beaver Lake Copper Adit)*

Exposure is very near the back of the adit, on the north side. The total thickness of the section equals the height of the adit. The radioactivity measurements may be somewhat elevated by radon accumulation.

Thickness (cm)	Radioactivity ("mR/hr")	Lithologic description
≥ 62	.04	Between medium gray (N5) and medium dark gray (N4). Medium-grained, very micaceous sandstone.
23	.06	Dusky-brown (5YR2/2) (weathered color), formerly calcareous sandstone from which the calcite has weathered.
24	.06	Between greenish gray (5G6/1) and dark greenish gray (5G4/1). Interbedded shale and siltstone, containing malachite in trace amounts.
≥ 73	.04	Grayish-red (10R4/2) shale and fine-grained sandstone-clast conglomerate in a siltstone matrix; contains calcite veinlets.

Both the low assay values for U_3O_8 and the observed radioactivities of only about 0.05 "mR/hr" suggest that the prospect is of little interest with respect to uranium.

Klemic Locality 9

1. LOCATION:
   (a) The area of radioactive rock is on the Beaver Lake Lodge tract in the bed of an abandoned north-south road between the former Beaver

Lake Hotel and the M. Deckman house on the R. Doebler tract. The area is 57 m (187 ft) approximately N25°W of the Beaver Lake Lodge-R. Doebler property boundary across the old road. This area is 0.24 km (0.15 mi) S23°W of the present Beaver Lake Lodge, 0.33 km (0.21 mi) south-southwest of the outlet of Beaver Lake, and about 0.65 km (0.40 mi) northeast of the crest of Barrett ("Bad") Hill, Penn Township, Lycoming County.

(b) Latitude: 41°17′28″N
Longitude: 76°35′32″W

2. ASSAYS: Because the reported occurrence consists of float, no assay samples were collected. Radiometric assays of the two flat float blocks yielded 150 and 180 ppm eU.
3. MINERALOGY: Neither copper nor uranium minerals were observed.
4. GEOLOGIC DESCRIPTION: The area described by Klemic (1962, p. 278) as consisting of "Outcrop in old road about 700 feet [200 m] south of outlet of Beaver Lake" was partially excavated and found to consist of two large float blocks in the 0.5- to 1-m (1.6- to 3.3-ft) size range. The total radioactive area is only a few square meters (few tens of square feet) at best and the blocks could have been hauled in when fill was added to the road. When cleared off, the two float blocks yielded 0.6 and 0.25 "mR/hr" (maximum), 0.15 and 0.15 "mR/hr" (average), and radiometric assays of 150 and 180 ppm eU, respectively.

A one-half-meter square (5-square-foot) area 19 m (62 ft) S9°W of the float block yielded approximately 300 cps with the scintillometer through 5 cm (2 in.) of soil humus. It consists of gray, thin-bedded, fine-grained micaceous sandstone that is probably in place. The cleared, flat surface yields 0.04 "mR/hr" and 120 ppm eU. Although this site is on approximately the same horizon as McCauley prospect 19, no additional reduced rocks or radioactive anomalies were found uphill to the west to the C. Myers-R. Doebler-Beaver Lake Lodge property corner. The lithologic similarity between the 19-m S9°W site and the roadbed blocks suggests that the latter may have been transported from the former area.

McCauley Prospect 18

(Klemic Locality 11; Avery Brothers Uranium Adit)

1. LOCATION:

(a) The adit is located on the Cleon Myers property on the southwest slope of Barrett ("Bad") Hill overlooking the west branch of Beaver Run. The adit floor is 3.4 m (11 ft) above the level of a northwest-southeast-trending bench which switches back from a northwest-trending private road from the Beaver Lake-Ebenezer Church road to the meadow at the top of Barrett Hill. This private road leaves the public highway just east of Cleon Myers' private driveway. The adit is N19°W of this driveway entrance and N15°W of the house. The adit is at an elevation of approximately 300 m (980 ft), 0.31 km (0.19 mi) northwest of the junction of the Beaver Run branches, and 1.25

km (0.78 mi) southwest of the outlet of Beaver Lake, Penn Township, Lycoming County.

(b) Latitude: 41°17′07″N
Longitude: 76°36′00″W

2. ASSAYS: Lacking *in situ* mineralization, the authors randomly selected from near the adit entrance chips of rock that showed at least a speck of copper bloom. The resulting blend of over 135 chips of gray siltstone and shale contains 700 ppm U_3O_8, 2 percent copper, 0.96 troy oz/ton silver, 640 ppm arsenic, and 50 ppm molybdenum. See sample MHK 792, Appendix 3.
3. MINERALOGY[1]:
   (a) Major: Djurleite in shrinkage cracks in vitrain, as spherical and cylindrical replacements typically about 1 cm (0.4 in.) in diameter,[2] and finely disseminated grains,[3] all in gray sandstone; malachite as crusts, sometimes micro-botryoidal, in and near djurleite, on bedding partings, on joint surfaces, in and/or near "chalcocite" partial replacements of carbonaceous plant fragments, and as interstitial grains, all in gray shale, siltstone, and sandstone.

   (b) Minor: Brochantite as transparent emerald-green coatings, crystalline micro-botryoids, and microcrystals; chrysocolla as green to light-blue crusts; chalcophyllite as bluish-green six-sided microcrystals and micaceous crusts; and olivenite as light-gray and brown, pale-olive-green, and yellowish crusts which sometimes exhibit radiated and stellated fibers; all associated with djurleite, in and/or near "chalcocite" partial replacements of carbonaceous plant fragments, and on joint surfaces and bedding partings.

   (c) Trace: Tyrolite as blue-green, bladelike microlaminae, usually radiated to stellated, on bedding partings and joint surfaces in gray sandstone; metazeunerite as rare, pale-yellow-green, tabular microcrystals closely associated with chalcophyllite, olivenite, and tyrolite; metazeunerite-meta-uranospinite(?) solid solution as yellow-brown, micaceous, tabular microcrystals in micro-botryoidal groups produced, perhaps, by a divergent radiating habit; azurite as rare coatings and interstitial micrograins; langite and/or posnjakite(?) as rare blue microcrystals and coatings on "chalcocite"; quartz as thin crystalline seams in and/or through djurleite as replacement of carbonaceous material between vitrain and gray sandstone, and quartz as crystalline and microcrystal partial replacement of carbonaceous plant fragments in grayish-red sandstone; "apatite" as rare phosphatic fish remains, including complete scales of *Holoptychius* sp., in oxidized and reduced rock, one fish remain in gray sandstone showing trace "chalcocite" replacements and green copper-mineral

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[1] The majority of mineral descriptions are from specimens collected near the entrance to the adit circa 1958 by Hoff.

[2] The oblong shape and circular cross sections suggest possible replacement of coprolites.

[3] In polished section, the disseminated djurleite was observed to contain blebs of bornite with thin digenite rims. Chalcopyrite is a rare associate of the bornite.

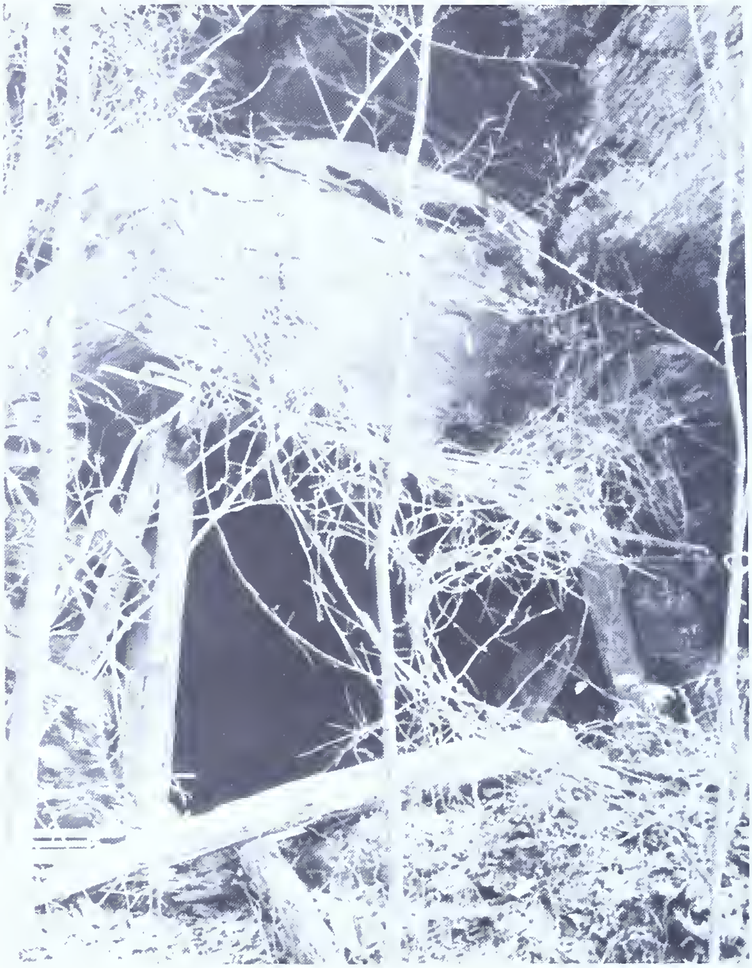

Figure 54. Entrance to McCauley prospect 18 (Klemic locality 11; Avery Brothers uranium adit), 1.25 km (0.78 mi) southwest of the outlet of Beaver Lake.

pigmentation; iron oxide with an admixture of an unknown secondary copper mineral as black, lustrous to earthy coatings on bedding partings and joint surfaces in gray sandstone; unidentified yellow and brownish-yellow secondary uranium minerals; cuprite as red to orange-red micrograins in gray sandstone; cuprosklodowskite as micro-botryoids with lime-green radiated cores and pale-green silky rims; and kasolite as golden microcrystalline crusts.

4. GEOLOGIC DESCRIPTION: The Avery Brothers uranium adit is approximately 9 m (30 ft) long, 2 m (7 ft) wide, and 2.5 m (8 ft) high and trends about N27°E. The miners were overly zealous in their work, and essentially no mineralization remains in place.[1] Despite the substantial steel I-beams (17 by 30.5 cm (6.7 by 12 in.) in cross section) supporting

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[1] According to Mr. Cleon Myers (personal communication, November 6, 1978), excessively large blasting charges set by the Avery brothers pulverized the good limb-replacement ore in the adit and scattered it over several acres, much like a giant muzzle-loader.

the entrance (Figure 54), the adit was judged too unsafe for detailed study. The tape-and-compass sketch map (Figure 55) should be considered only approximate because of the difficulties caused by the many fallen timbers (Figures 56 and 57).

Too little mineralized rock remains *in situ* to interpret the occurrence properly, but it apparently was not a typical channel-bottom deposit made up of calcareous breccia. Mr. Donald Avery (personal communication, February 10, 1980), reported that a carbonaceous seam approximately 2.4 m (8 ft) long was the most conspicuous feature in the highly mineralized zone. A specimen collected (in approximately 1958) from near the adit's entrance suggests that Mr. Avery's seam was probably a large vitrain- and djurleite-bearing log measuring more than 9 cm (3.5 in.) perpendicular to the log's long axis. Djurleite filling shrinkage cracks in a vitrain seam up to 1 cm (0.4 in.) thick occurs on the mold of

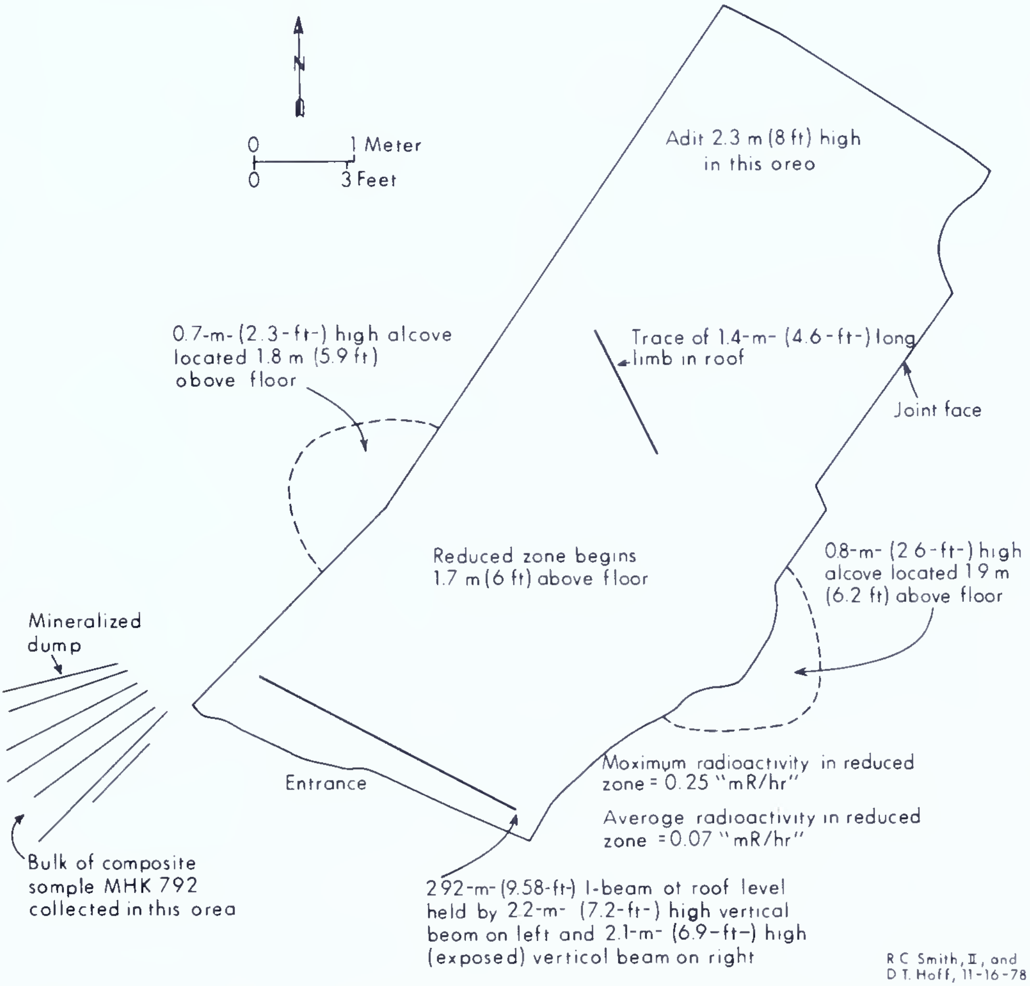
N
0 1 Meter
0 3 Feet
Adit 2.3 m (8 ft) high in this area
0.7-m- (2.3-ft-) high alcove located 1.8 m (5.9 ft) above floor
Trace of 1.4-m- (4.6-ft-) long limb in roof
Joint face
Reduced zone begins 1.7 m (6 ft) above floor
0.8-m- (2.6-ft-) high alcove located 1.9 m (6.2 ft) above floor
Mineralized dump
Entrance
Maximum radioactivity in reduced zone = 0.25 "mR/hr"
Average radioactivity in reduced zone = 0.07 "mR/hr"
Bulk of composite sample MHK 792 collected in this area
2.92-m- (9.58-ft-) I-beam at roof level held by 2.2-m- (7.2-ft-) high vertical beam on left and 2.1-m- (6.9-ft-) high (exposed) vertical beam on right
R C Smith, II, and D T. Hoff, 11-16-78

Figure 55. Sketch map of the floor level of McCauley prospect 18, 1.25 km (0.78 mi) southwest of the outlet of Beaver Lake, Penn Township, Lycoming County. The adit floor level is 3.4 m (11 ft) above the bench level.

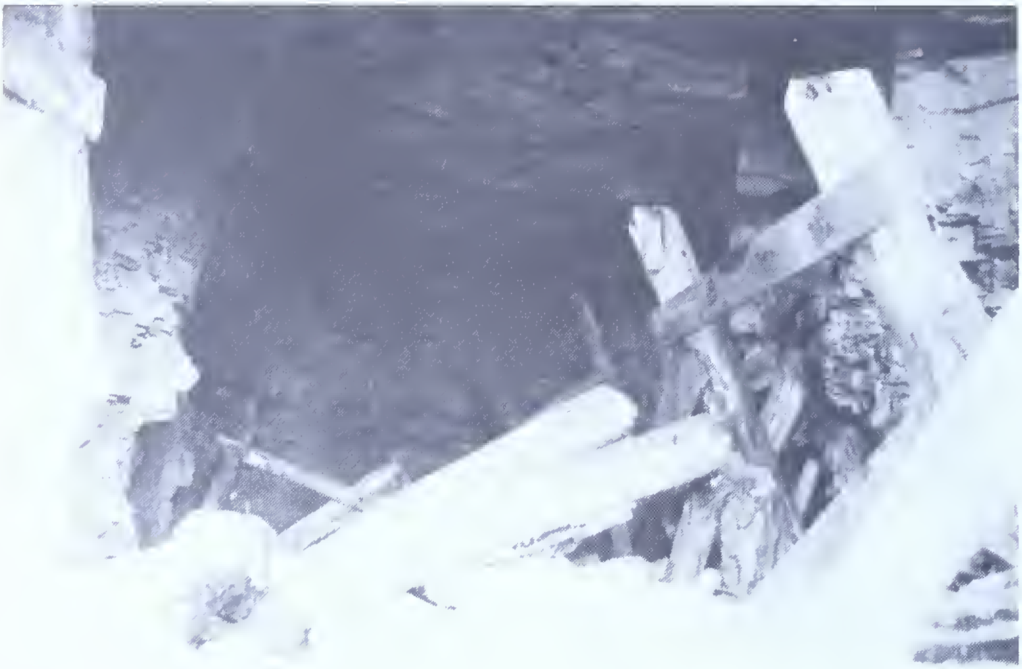

Figure 56. Close-up view of fallen timbers, looking into McCauley prospect 18, 1.25 km (0.78 mi) southwest of the outlet of Beaver Lake.

the log in the sandstone. This large log, associated "chalcocite" (djurleite?) replacements of limbs and twigs, and djurleite as peculiar spherical and cylindrical replacements apparently occurred in a gray siltstone-sandstone lens within reddish siltstone. The impression of another 1.4-m- (4.6-ft-) long log is still observable in the adit roof.

Donald and Emmitt Avery mined the richest samples from the adit during the spring and summer of 1956. However, adit development and exploratory drilling continued through 1958.

Donald Avery (personal communication, February 10, 1980) stated that three exploration holes totalling 209 m (686 ft) in depth were drilled near the adit as follows:

Hole no.[1]	Approximate depth		Approximate location
1	61 m	200 ft	Bench, 3.5 m (11.5 ft) below floor of adit.
2	>61 m	>200 ft	Cliff top, 30 m (100 ft) northeast of, and above, adit.
3	>61 m	>200 ft	At a higher elevation, 92 m (300 ft) north-northwest of adit.

The Avery brothers tested the three holes at the time of drilling with a Geiger probe lowered by a wire reel. Above-average radioactivities were reported, but depths and hole locations were not recorded. However,

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[1] Hole numbers arbitrarily assigned.

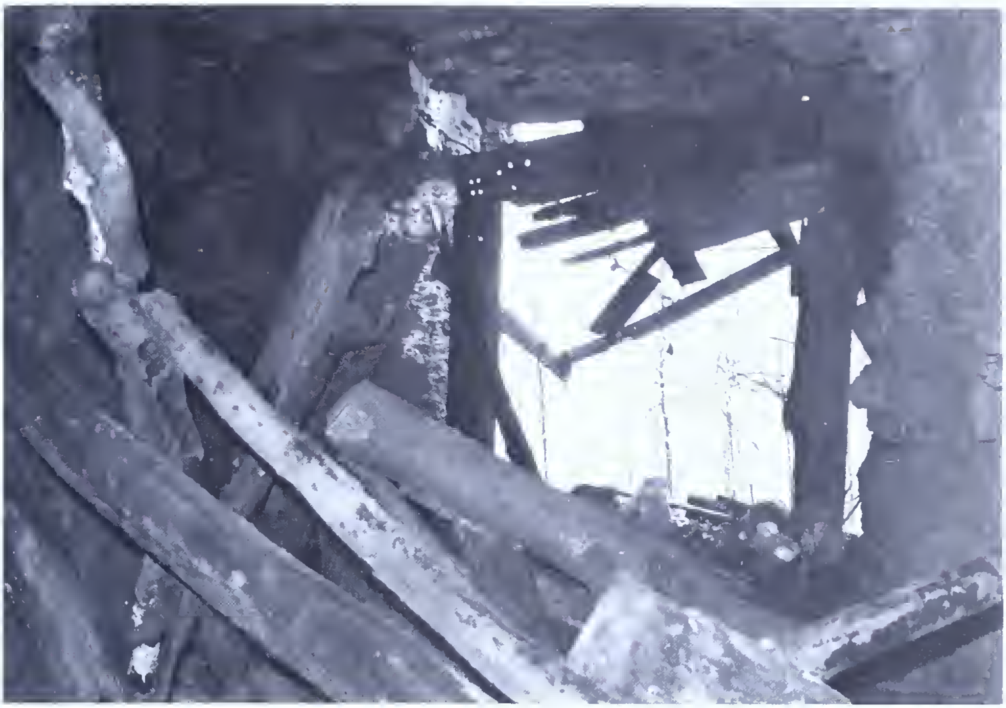

Figure 57. View looking out of McCauley prospect 18, 1.25 km (0.78 mi) southwest of the outlet of Beaver Lake. Note the steel I-beams (with holes) on the left (southeast) side of the entrance.

drill-hole radioactivities were said to be not as high as those observed in the adit during mining operations.

According to Cleon Myers (personal communications, numerous dates, 1958–81), the Geiger counter sounded like "eggs-a-fryin'" upon his clandestine approach to the testing of hole 1.

Because mineralization occurs at so many exposures at approximately this horizon, further investigation of the lower Catskill Formation southwest of Beaver Lake may be warranted.

McCauley Prospect 19
(Klemic Locality 10)

1. LOCATION:

(a) From southwest to northeast, McCauley prospect 19 consists of the outcrop area of the upper limonitic uranium zone, two adits, a possible caved adit, and the northeast end of the outcrop in which the possible caved adit is located.

McCauley prospect 19 is on the Reuben Doebler tract on the east side of Barrett ("Bad") Hill, at an approximate elevation of 299 m (980 ft) toward the northeast end of the flat at that elevation. The southwest adit, chosen as a reference point, is located approximately

38 m (125 ft) northeast of a small stream with falls (shown on Plate 1 as a tiny gulley) and N42°W of the new (1979) M. Deckman house. This locates the southwest adit 0.61 km (0.38 mi) southwest of the outlet of Beaver Lake and 0.79 km (0.49 mi) northeast of the confluence of the east and west branches of Beaver Run, Penn Township, Lycoming County. It is approximately 195 m (640 ft) southwest along the swampy trail directly below the southwest adit to the paved Beaver Lake Road. This trail intercepts Beaver Lake Road 110 m (360 ft) southwest of the bridge.

The channel-sample and stratigraphic-section site for the upper limonitic uranium zone is 51 m (167 ft) S53°W of the southwest adit and 19.7 ± 2 m (65 ± 7 ft) in elevation above the base of the new house.

The entrance to the northeast adit is 5.3 m (17 ft) west of the cliff face at a point 29 m (95 ft) N36°E of the southwest adit. The possible caved adit is located approximately 45 m (150 ft) approximately N15°E of the northeast adit and about 6 m (20 ft) lower in elevation. This is about 10 m (33 ft) from the north end of the cliff face in which the southwest and northeast adits are located. It is the northeast end of this last outcrop to the northeast that is also mineralized.

	Outcrop of the upper limonitic uranium zone	Southwest adit	Northeast adit	Possible caved adit and outcrop
(b) Latitude:	41°17′20″N	41°17′21″N	41°17′21″N	41°17′22″N
Longitude:	76°35′38″W	76°35′37″W	76°35′36″W	76°35′35″W

2. ASSAYS: A 31-cm (12-in.) channel sample of micaceous, gray sandstone from the upper limonitic uranium zone contains 509 ppm U_3O_8, 2,600 ppm copper, and 42 ppm molybdenum. A composite sample of gray calcareous breccia and sandstone from the southwest-adit dump contains 40 ppm U_3O_8, 1,150 ppm copper, 225 ppm arsenic, and 290 ppm lead. A composite sample of gray calcareous breccia and sandstone from the northeast-adit dump contains 62 ppm U_3O_8, 4,150 ppm copper, and 165 ppm arsenic. See samples MHK 770, 764, and 736, Appendix 3.
3. MINERALOGY:

Upper limonitic uranium zone

(a) Major: "Limonite," sometimes containing unknown secondary copper minerals as iridescent stainings, coatings, and microbotryoids on bedding and joint partings and outcrop surfaces.
(b) Minor: Malachite as stainings on bedding partings and as interstitial micrograins.
(c) Trace: Barite as micaceous crusts of thin lathlike to tabular microcrystals on bedding partings; chrysocolla as green crusts on bedding partings.

Southwest adit

(a) Major: None.
(b) Minor: Chalcocite as globules up to 1 cm (0.4 in.) in calcareous breccia; also probable "chalcocite" plus digenite(?) associated

with rare quartz as partial replacements of carbonaceous plant fragments in calcareous breccia; white calcite filling shrinkage cracks in carbonaceous plant fragments and cross-fiber fillings, both in sandstone. Malachite stains in calcareous breccia and sandstone. Coarsely crystalline calcite in calcareous breccia.

(c) Trace: In sandstone—galena in shrinkage cracks in carbonaceous plant fragments, also associated with chalcopyrite and bornite in same; and chalcopyrite and pyrite(?) as microdisseminations. Pyrite(?). Tennantite(?). "Apatite" as phosphatic fish remains in calcareous breccia.

Possible caved adit and outcrop

(a) Major: None.

(b) Minor: "Limonite" as rims in pits believed to have once contained approximately 3 mm pyrite nodules.

(c) Trace: None.

Northeast adit

(a) Major: None.

(b) Minor: None.

(c) Trace: In adit—"limonite" as crusts; rare malachite; and langite and/or posnjakite as sky-blue, scaly to acicular crusts on and near bornite and "chalcocite" partial replacements of carbonaceous plant fragments. On dump—pyrite and rare chalcopyrite in fine-grained, calcareous sandstone; and "apatite" as phosphatic fish remains with rare associated chalcopyrite, sometimes filling fossae, in calcareous breccia.

4. GEOLOGIC DESCRIPTION: The upper limonitic uranium zone consists of natural outcrop and float blocks. At the reference site, where the stratigraphic description was made and channel sample was taken, a radiometric assay yielded 600 ppm eU. For 3 m (10 ft) of outcrop along strike to the northeast an average of about 1,000 cps was obtained with the Mt. Sopris scintillometer; local maxima were $\geq$ 5,000 cps. The zone was traced 2.2 m (7 ft) further northeast through the leaves, and readings were $\geq$ 200 cps. From the reference site southwest, continuous readings of more than 500 cps were obtained for 3.5 m (11 ft), the average being about 1,000 cps. Thus, this zone can be traced for 8.7 m (28 ft) with an instrument. Where exposed, the zone is characterized by subtle limonite staining. One outcrop on the same horizon, located about 35 m (115 ft) S83°W of the reference site, yielded 200 ppm eU on a bedding parting. Another outcrop about 14 m (46 ft) still farther to the west yielded 100 ppm eU on a vertical fracture through the laminated sandstone at the most favorable place. The reduced zone is 1.5 m (5 ft) thick at the reference site. The stratigraphy at that location is described in detail in Table 36.

The southwest adit is 13.6 m (45 ft) long, about 2 to 3 m (7 to 10 ft) wide, and about 1.5 m (5 ft) high. It trends N80°W and has a background radioactivity of only 0.02 to 0.03 "mR/hr." It is judged to be extremely unsafe. Drywall supports on both sides of the adit entrance have failed to prevent roof collapse (Figure 58). Only dump samples were col-

Table 36. *Stratigraphic Section of Catskill Formation Rocks at McCauley Prospect 19 (Upper Limonitic Uranium Zone)*

Exposure is near the center of a 6.5-m-(21-ft-) long outcrop.

Thickness (cm)	Radioactivity ("mR/hr")	Lithologic description
>50	.03	Between grayish red (5R4/2) and brownish gray (5YR4/1). Fine grained, laminated to thin-bedded, crossbedded sandstone.
85	.03	Medium-gray (N5), fine- to medium-grained, laminated to thin-bedded sandstone.
31	.11	Between medium gray (N5) and medium dark gray (N4). Fine-grained, micaceous, thin-bedded sandstone which has undulating laminations at the top. This assayed unit contains minor malachite and abundant "limonite" on bedding surfaces, and sparse carbonaceous plant fragments.
35	.04	Medium-gray (N5), fine-grained, laminated to thin-bedded sandstone.
>200	.03	Between grayish red (5R4/2) and brownish gray (5YR4/1), except near the top, where it is medium dark gray (N4). Fine-grained, thin-bedded sandstone.

lected. The rock on the dump, just east of the adit entrance, suggests that the adit contained reduced calcareous breccia and sandstone with carbonaceous plant fragments.

The northeast adit is 7.6 m (25 ft) long, 3.0 m (10 ft) wide, and 1.7 m (5.6 ft) high (Figure 59). It trends N62°W and has a background radioactivity that is typically only 0.02 to 0.03 "mR/hr." Slightly anomalous radioactivity occurs near very localized, limonite-stained areas on the southwest wall. The highest radioactivity, 0.07 "mR/hr," was observed at a fluorescent (UV) green film. There is a moderate amount of waste rock piled along the southwest side of the adit. Trace spots of malachite occur near floor level beyond this rubble pile. Near the entrance, the adit roof is slickensided and limonite stained. The slickenlines trend approximately N10°W and plunge approximately 18°S. The relative movement is uncertain. The adit appears to have been excavated in gray, calcareous, fine-grained sandstone and minor calcareous breccia.

The rock on the dump that begins 5.3 m (17 ft) east of the adit entrance is gray, shale-chip-rich, calcareous, fine-grained sandstone and minor calcareous breccia. It contains uncommon disseminated pyrite and rare chalcopyrite. One small spot in the ledge face about 6 m (20 ft) north of this adit yields a maximum radioactivity of 0.13 "mR/hr."

The questionable caved adit appears to have been excavated a very short distance into a gray to slightly maroon, crossbedded sandstone. No tool or drill-hole marks were found to prove that the undercut was manmade. The background radioactivity at the possible adit is only 0.02 "mR/hr," and no radioactivity anomalies were found.

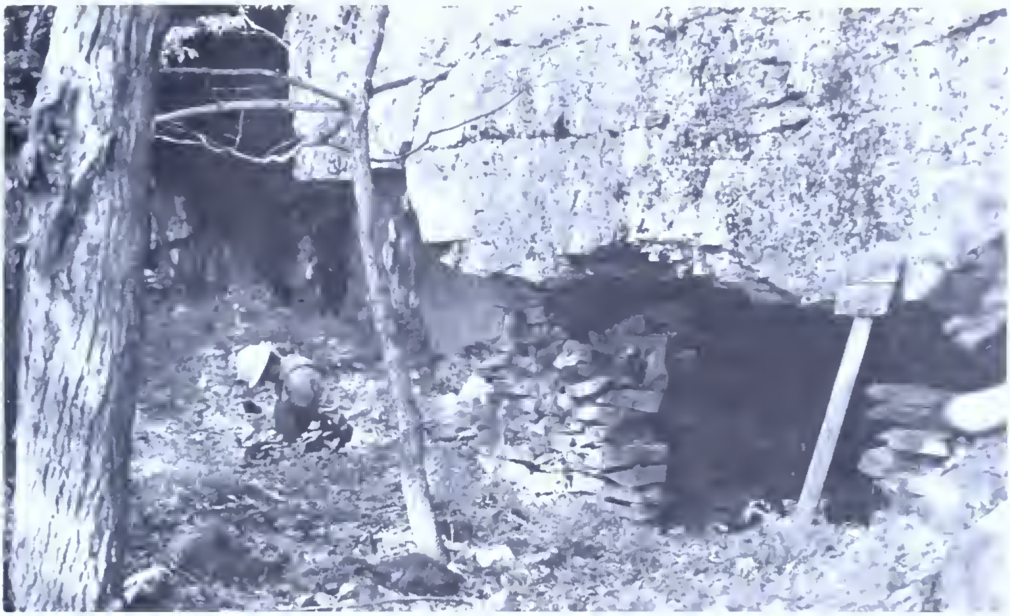

Figure 58. Drywall support for the southwest adit, McCauley prospect 19.

The northeast end of the outcrop, in which the questionable caved adit is located, has a small radioactive limonite-stained zone near the top of the reduced zone. The average radioactivity of this zone is 0.08 "mR/hr" over a probable thickness of 10 cm (4 in.) and a length of 1 m (3 ft), but a tree root has made estimation difficult. A high-graded gray sandstone hand sample yielded 0.2 "mR/hr." The laminated sandstone in this zone appears to have contained approximately 3 mm pyrite nodules that have weathered out and left "limonite" rims in the holes. This main radioactive limonite-stained zone is about 1 m (3 ft) below the transition to oxidized sandstone. A radioactive limonite-stained zone about 15 to 20 cm (6 to 8 in.) below the main ore yields about 0.6 "mR/hr" over a strike length of about a meter (3 ft). These mineralized zones are similar in stratigraphic position and lithology to the upper limonitic uranium zone at the southwest end of McCauley prospect 19.

The thickness of the reduced zone at McCauley prospect 19 varies from 1.5 m (5 ft) at the upper limonitic uranium zone on the southwest end, to $\geq$ 3 m (10 ft) at the southwest adit, to $\geq$ 4 m (13 ft) at the northeast adit, to $\geq$ 5 m (16 ft), but probably less than 8 m (26 ft), at the possible caved adit at the northeast end. The distance from the southwest to northeast ends of mineralization is over 153 m (500 ft), not including the float block at Klemic locality 9. These distances and the grade at the upper limonitic uranium zone at the southwest end suggest that this is a relatively rich ocrurrence for this district.

Compared with the reduced zones at most prospects in the project area, the reduced zone at McCauley prospect 19 contains most of the localized uranium near the upper contact rather than near the base of a

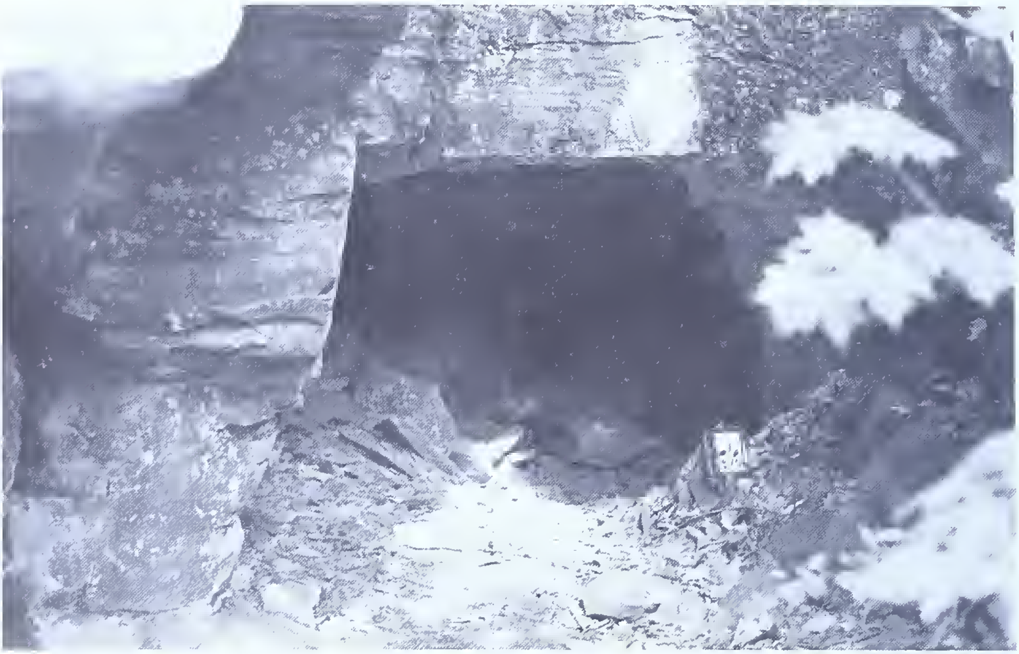

Figure 59. Entrance to the relatively barren northeast adit, McCauley prospect 19. The dump 5 m (16 ft) to the east is richer in copper than the eye suggests.

channel. Because of the slickensiding and recrystallized and cross-fiber calcite, at least minor remobilization during the Alleghanian orogeny cannot be ruled out.

In terms of commercial mineralization, it should be noted that the largest reduced zones in the district are typically the leanest, suggesting that a limited uranium source during deposition can either be highly concentrated in a small mass of reduced rock or diluted through a large mass. Reconcentration of uranium in the fine-grained sedimentary rocks of the lower Catskill Formation seems to be limited by permeability to very localized tectonic-hydrothermal effects. This, and the possibilities for remobilization in the upper Catskill, are discussed in the section on "Genesis."

McCauley Prospect 21

1. LOCATION:
   (a) The prospect is located on the Leon Myers property on a west-facing slope in the second hollow upstream off the west branch of the headwaters of Beaver Run, 1.43 km (0.89 mi) north-northwest of the confluence with the east branch, Penn Township, Lycoming County. The prospect overlooks a sphagnum bog at an elevation of 305 m (1,000 ft), and the prospect itself is at a level 18 ± 1 m (59 ± 3 ft) above the bog. An old northwest-trending trail passes to the north of the occurrence, and the fence line between the Cleon Myers and

Leon Myers farms is located 20 m (66 ft) south of the prospect reference site. The prospect area is 1.27 km (0.79 mi) due west of the outlet of Beaver Lake.

(b) Latitude: 41°17′39″N
Longitude: 76°36′21″W

2. ASSAYS: A 26-cm (10-in.) channel sample of gray to reddish-gray sandstone and gray calcareous breccia containing carbonaceous plant fragments and malachite has 300 ppm U_3O_8 and 1.7 percent copper. A 15-cm (6-in.) channel sample of atypically rich "maroon" sandstone from the site 34 m (112 ft) south of the reference point contains 3,200 ppm U_3O_8, 4,600 ppm copper, 1,200 ppm arsenic, and approximately 300 ppm yttrium and 700 ppm zirconium.[1] See samples MHK 775 and 776, Appendix 3.
3. MINERALOGY:
   (a) Major: Malachite as coatings on bedding partings and joint surfaces, associated with carbonaceous plant fragments and "chalcocite," and as interstitial grains.
   (b) Minor: Zeunerite as small, green, micaceous flakes at the site 34 m (112 ft) south of the reference point; "chalcocite" as replacements of carbonaceous plant fragments and micrograins in calcareous sandstone; and chrysocolla as olive-green, medium-green, and light-blue crusts on bedding partings and carbonaceous plant fragments.
   (c) Trace: Yellow, powdery, unidentified material in a matrix of "maroon," crossbedded sandstone from the site 34 m (112 ft) south of the reference point; straw to brownish-yellow, unidentified secondary uranium mineral (or minerals) associated with malachite at the site 51 m (167 ft) south of the reference point; and langite and/or posnjakite as sky-blue coatings and microprisms associated with emerald-green, vitreous brochantite on "chalcocite" at the reference point.
4. GEOLOGIC DESCRIPTION: McCauley prospect 21 consists of a 50-m- (165-ft-) long series of natural and minimally prospected underhangs. To the north of the main prospect underhang, where the representative channel sample and stratigraphic description (Table 37) were obtained, the potential ore horizon is covered and could not be detected through the soil with the Mt. Sopris scintillometer. The locations and radioactivities of mineralized intervals in the "ore" horizon along a traverse north and south of the channel-sample site are presented in Table 38. The stratigraphic section 34 m (112 ft) south of the reference site is presented in Table 39.

   Because of the relatively high U_3O_8 contents and the location along a stratigraphic horizon that has numerous copper-uranium occurrences in "Copper Hollow" to the southeast, further study in the area may be warranted. Moderate arsenic contents at several of the occurrences along this horizon may indicate a marine influence.

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[1] The yttrium and zirconium are hypothesized to be related to a possible abundance of heavy minerals, such as zircon, in the crossbedded sandstone.

Table 37. *Stratigraphic Section of Catskill Formation Rocks at McCauley Prospect 21*

Exposure is at the 0-m, main prospect overhang, channel-sample site and reference point, 20.5 m (67.2 ft) north of the Cleon Myers-Leon Myers property line.

Thickness (cm)	Radioactivity ("mR/hr")	Lithologic description
>120	.02	Grayish-red (5R4/2), fine-grained, medium-bedded sandstone with undulating beds. The unit contains approximately 40 cm of medium-gray (N5), fine-grained, micaceous sandstone at the bottom.
23	.07	Between medium gray (N5) and medium dark gray (N4). Calcareous breccia; contains lenses of medium-grained sandstone between medium gray (N5) and brownish gray (5YR4/1). Seven centimeters of malachite-rich calcareous breccia at the bottom of the unit was included in the representative assayed sample.
>60	Top 16 cm .2 avg. .4 max. Below top 16 cm .07	Medium dark gray (N4) and between medium dark gray (N4) and brownish gray (5YR4/1). Fine- to medium-grained, micaceous, medium-bedded sandstone. The top calcareous 16 cm of this unit, which contains abundant carbonaceous plant fragments and malachite and has color mottling caused by oxidation of limited areas, is included in the 23-cm-thick representative assayed sample.

Table 38. *Radiometric Measurements along McCauley Prospect 21*

Intervals are along the "ore" horizon south of the main McCauley 21 prospect overhang, 1.3 km (0.81 mi) west of the outlet of Beaver Lake.

Location	Radioactivity[1] (counts per second)	Radiometric assay (ppm eU)	Comments
North end			
−10 to −1 m (−33 to −3 ft)			Covered.
−1 to +3.5 m (−3 to +11.5 ft)	200		
0 m (channel-sample site)	2,000		On copper-rich area of representative channel sample.
+3.5 to 9 m (+11.5 to 29.5 ft)			Covered.
9 to 12.5 m (29.5 to 41.0 ft)	200		
10.3 m (33.8 ft)		600	Two richest spots in interval.
12.2 m (40.0 ft)		500	
12.5 to 15.0 m (41.0 to 49.2 ft)			Covered.

Table 38. *(Continued)*

Location	Radioactivity[1] (counts per second)	Radiometric assay (ppm eU)	Comments
15.0 m (49.2 ft)	300		
15.0 to 18.0 m (49.2 to 59.0 ft)	200		
17.2 m (56.4 ft)	600		
18.0 to 32.5 m (59.0 to 106.6 ft)	200		Partly covered.
20.5 m (67.2 ft)			Cleon Myers-Leon Myers property line.
32.5 to 36.5 m (106.6 to 119.7 ft)	200		
34 m (111.5 ft)	2,000		Overhang where atypical channel sample was collected and stratigraphy described (Table 39).
36.5 to 39.5 m (119.7 to 129.6 ft)	200		Covered.
40.5 m (132.8 ft)		50	
41.5 m (136.1 ft)		230	
45 ± 2 m (148 ± 7 ft)			On cliff.
51 m (167 ft)	3,500		Under float monolith with rich samples piled beneath.
53 m (174 ft)			Projects out onto substantial cliff.
South end			

[1] Data were collected with a Mt. Sopris SC-132 scintillometer.

Table 39. *Stratigraphic Section of Catskill Formation Rocks 34 m (112 ft) South of the Reference Point at McCauley Prospect 21*

Thickness (cm)	Radioactivity ("mR/hr")	Lithologic description
>50	.02	Grayish-red (5R4/2), fine-grained, micaceous sandstone with thin, undulating beds.
50	.3	Medium light gray (N6) to between grayish red (5R4/2) and blackish red (5R2/2) ("maroon"). Fine-grained, micaceous, medium-bedded sandstone with undulating beds. This unit cuts out the lower unit with approximately 15 cm of relief. The atypical assayed sample consists of 15 cm of the unit's "maroon" sandstone, which has an average radioactivity of 1.5 "mR/hr" and a maximum of 2.0 "mR/hr."

Table 39. *(Continued)*

Thickness (cm)	Radioactivity ("mR/hr")	Lithologic description
>20	.035	Grayish-red (5R4/2) interbedded shale and siltstone, containing medium-gray (N5) siltstone laminae near the top.

McCAULEY 22 CLUSTER

Edler Lake Uranium-Copper Occurrence

1. LOCATION:
   (a) The occurrence is located on the Edler tract beneath and on the northwest side of a N35°E-trending jeep trail, 60 m (200 ft) west of the end of the trail on the north shore of Edler Lake, Penn Township, Lycoming County. The occurrence is at the level of the trail where it is 5.5 m (18 ft) above the present level of the lake, which is moderately higher than the lake level shown on the 1970 topographic map, and 1.13 km (0.70 mi) southeast of Glen Mawr. From the outlet of the lake, it is 0.52 km (0.32 mi) northeast to the occurrence along a straight line or 0.65 km (0.40 mi) following the jeep trail.
   (b) Latitude: 41°18′20″N
   Longitude: 76°38′50″W
2. ASSAYS: A 65-cm (26-in.) channel sample of gray siltstone and sandstone contains 100 ppm U_3O_8, 700 ppm copper, and 575 ppm lead. See sample MHK 793, Appendix 3.
3. MINERALOGY:
   (a) Major: None.
   (b) Minor: Malachite as micro-botryoids and coatings on bedding partings, as finely disseminated grains, and associated with carbonaceous plant fragments, all in sandstone.
   (c) Trace: Rare unidentified yellow and orange coatings; unidentified pistachio-green "BB's" (millimeter-sized spheres), especially common along certain laminae; "chalcocite" as finely disseminated grains in gray sandstone; brochantite as finely crystalline bluish-green crusts intimately intergrown with malachite; barite as clear, thin, tabular microcrystals associated with the brochantite-malachite intergrowths; chrysocolla as rare green crusts in and/or near carbonaceous plant fragments; and black, lustrous to earthy, iron oxide coatings containing an admixture of an unknown secondary copper mineral.
4. GEOLOGIC DESCRIPTION: The occurrence, located by a car-borne scintillometer survey, was initially covered with leaves and humus except for an area a few centimeters long in the center of the road. This discovery outcrop was projected 10 m (33 ft) northeast to the edge of the road, where a moderately large, temporary excavation was made for the chan-

nel sample and stratigraphic description (Table 40). The mineralized horizon probably continues several meters farther east beneath colluvium, but could not be located around the eastern end of the lake.

One very localized area at the discovery site yielded a gross count of 1,300 cps and 500 ppm eU, whereas 1 m (3 ft) to the north a similar radiometric assay yielded 10 ppm eU. Ten meters (33 ft) to the east, measurements at the temporary excavation yielded a gross count of 1,500 cps and 600 ppm eU.

Some of the carbonaceous plant fragments in the 30-cm- (12-in.-) thick, upper, gray shale-siltstone unit are in possible original growth position rather than parallel to bedding.

Because the Edler Lake uranium-copper occurrence seems to be at the same horizon as McCauley prospect 22, the area between them was searched with a scintillometer, but with no success.

A third occurrence at approximately this horizon was also discovered during the car-borne survey. It is located on the north side of Edler Drive through the T. N. Evans tract at a point which is 0.79 km (0.49 mi) east by road from Edler's house and 0.43 km (0.27 mi) west by road from the secondary road from Ebenezer Church north to U.S. Route 220 (Plate 1). No excavation was undertaken. Measurement yielded a gross count of 1,500 cps and 600 ppm eU on a partly exposed gray sandstone bed. Further examination may be warranted.

Table 40. ***Stratigraphic Section of Catskill Formation Rocks at the Edler Lake Uranium-Copper Occurrence***

Exposure was at a temporary excavation on the northwest side of a jeep trail, approximately 60 m (200 ft) west of the trail's end at the full pool level of Edler Lake.

Thickness (cm)	Radioactivity ("mR/hr")	Lithologic description
>30	.15	Medium-dark-gray (N4), micaceous, laminated to thin-bedded siltstone. The unit contains carbonaceous plant fragments, some of which are oriented nearly perpendicular to bedding planes, and trace malachite on bedding partings.
32	.25	Medium-dark-gray (N4), fine-grained, micaceous, thin-bedded sandstone. The unit contains a moderate amount of malachite on bedding partings and has abundant plant fragments, some of which show little or no carbonaceous material.
>3	.20	Medium-dark-gray (N4) shale.

McCauley Prospect 22

1. LOCATION:
   (a) The prospect consists of two short adits, and most of the copper and uranium mineralization is nearer the southeast adit. The prospect is

located on the Bowling Green Corporation property on the southwest side of a hill at an elevation of about 326 m (1,070 ft), overlooking a bog. This area is 1.23 km (0.76 mi) south-southwest of Glen Mawr, 0.42 km (0.26 mi) west of the breast of Edler Lake dam, and 0.77 km (0.48 mi) southeast of the confluence of Lick Run and Muncy Creek, Penn Township, Lycoming County.

McCauley's (1961, p. 62) description places the prospect 1.3 km (0.8 mi) to the southwest of its actual location, and his latitude and longitude 4.35 km (2.7 mi) to the southeast in the adjacent quadrangle. Based on McCauley's Figure 13, his prospect 22 is the one described here despite the fact that no quarry floor was recognized during the present study.

The northwest adit is about 3 m (10 ft) above bog level and the southeast adit about 8 m (26 ft) above. The distance between the adits is 66.7 m (219 ft) and the bearing N30°W. The described sites are designated in meters northwest of the center of the southeast adit.

	Northwest adit	Southeast adit
(b) Latitude:	41°18′11″N	41°18′10″N
Longitude:	76°39′27″W	76°39′24″W

2. ASSAYS: Adjacent channel samples of 36 cm (14 in.) of gray sandstone containing carbonaceous plant fragments from the northwest side of the southeast adit have 130 and 260 ppm U_3O_8, 1.25 and 1.35 percent copper, 460 and 680 ppm arsenic, 900 and 1,000 ppm lead, and 27 and 28 ppm silver. The samples were collected by R. C. Smith and R. B. Koeberle, respectively. A 20-cm (8-in.) channel sample of carbonaceous sandstone from a small prospected face 10.2 m (33.5 ft) northwest of the southeast adit contains 1,390 ppm U_3O_8, 1.35 percent copper, 2,450 ppm arsenic, 7 ppm selenium, and 1.66 troy oz/ton silver. See samples MHK 735, 734, and 728, Appendix 3.

The duplicate samples and analyses for the southeast adit were taken to obtain an estimate of sampling and analytical error. Except for the difference in U_3O_8, the errors are considered acceptable.

3. MINERALOGY:

Northwest adit

(a) Major: None.
(b) Minor: None.
(c) Trace: "Apatite" as phosphatic fish remains in calcareous breccia. Rare malachite stains in brownish-gray sandstone.

19.2 m (63 ft) northwest of southeast adit

(a) Major: None.
(b) Minor: None.
(c) Trace: Metazeunerite-metatorbernite as apple-green micaceous flakes along plant fossils; malachite and rare beta-uranophane as yellow coatings.

10.2 m (33.5 ft) northwest of southeast adit

(a) Major: Malachite as crusts strongly associated with carbonaceous plant fragments.

(b) Minor: Chrysocolla as crusts.

(c) Trace: Tennantite associated with anilite(?) as sectile replacements having a dark-brownish streak; chalcophyllite as bluish-green, micaceous, six-sided microcrystals; rare langite as blue micaceous plates on "chalcocite"; posnjakite as sky-blue platy microcrystals; olivenite as rare pale-green acicular microcrystals with a vitreous to adamantine luster, and also as coatings of pale-green to light-gray, radiated and stellated fibers; cerussite as white crystalline crusts; brochantite; and unidentified pistachio-green "BB's" in sandstone.

6 m (20 ft) northwest of southeast adit

(a) Major: None.

(b) Minor: Malachite as crusts and sparse globules sometimes enclosed in rare etched crystalline calcite.

(c) Trace: Linarite-like mineral as blue platy crystals, sometimes with bluish-white rims and coatings; kasolite as massive yellow to brownish-yellow coatings and rare greenish-yellow micro-botryoids; brochantite as emerald-green crystalline crusts; chrysocolla; cerussite as white, crystalline crust; and anglesite as white crusts and microcrystals.

Southeast adit and dump

(a) Major: Malachite as crusts, sometimes micro-botryoidal, associated with carbonaceous plant fragments.

(b) Minor: Chrysocolla as medium- to olive-green crusts.

(c) Trace: Azurite as rare, deep-blue crystalline coatings; metazeunerite-metatorbernite; chalcophyllite as bluish-green crystalline coatings; digenite as replacements of carbonaceous plant fragments; olivenite as silky coatings of pale-green radiated fibers; brochantite; "apatite" as phosphatic fish remains; and quartz as a partial replacement of a carbonaceous plant fragment.

4. GEOLOGIC DESCRIPTION: The northwest adit is 1.7 m (5.6 ft) wide at the entrance, 1.5 m (5 ft) high, and 4.8 m (15.7 ft) long. The adit trends N10°E. The target bed appears to have been a 6- to 15-cm- (2.5- to 5-in.-) thick, grayish-brown calcareous breccia containing reddish shale clasts and phosphatic fish remains. The calcareous breccia marks the base of a fining-upward cycle that has 35 cm (14 in.) of dark-reddish-brown (10R3/4) shaly siltstone below and 70 cm (28 in.) of grayish- to reddish-brown (5Y4/1 to 5R4/2), flaggy sandstone above. The average radioactivities of the upper sandstone, middle calcareous breccia, lower shaly siltstone, and dump are 0.02 to 0.03, 0.07 ± 0.04, 0.02 to 0.03, and 0.04 "mR/hr," respectively.

Bedding at the northwest adit dips about 5°NE. The trend of crossbedding appears to be consistent; the one set that was measured dips 25 degrees in a direction of N25°W. Crossbedding is well displayed at the northwest adit, and ripple bedding is well displayed in the large slumped block just northwest of the adit. Joints trend N33°E and are vertical.

The 19.2-m site consists of a partly oxidized sandstone section which has large fossil plant traces exposed in a small underhang that is at least in part natural.

The 10.2-m site is a small face that was prospected, based on the remains of drill holes. Here, the uraniferous zone is a 20-cm- (8-in.-) thick reduced sandstone that has a typical radioactivity of 0.5 to 1.0 "mR/hr." Tennantite was observed here as partial replacements of carbonaceous plant fragments. Secondary copper arsenates include chalcophyllite and olivenite.

The 6-m site consists of a prospected face which has a 30-cm- (12-in.-) thick and 70-cm- (28-in.-) long mineralized zone. The typical radioactivity is 1 to 2 "mR/hr" and the maximum is 4 "mR/hr." A moderate amount of kasolite and a linarite-like mineral were found in mottled brownish-gray (5YR4/1) to grayish-red (5R4/2), micaceous, fine-grained sandstone to siltstone. No primary lead minerals were observed at this site.

The southeast adit (Figure 60) is 1.55 m (5 ft) wide at the entrance, 1.75 m (5.7 ft) high, and 4.0 m (13 ft) long. The adit follows jointing, here trending N33°E and dipping vertically. The target bed appears to have been a 35-cm- (14-in.-) thick, medium-gray, fine-grained sandstone

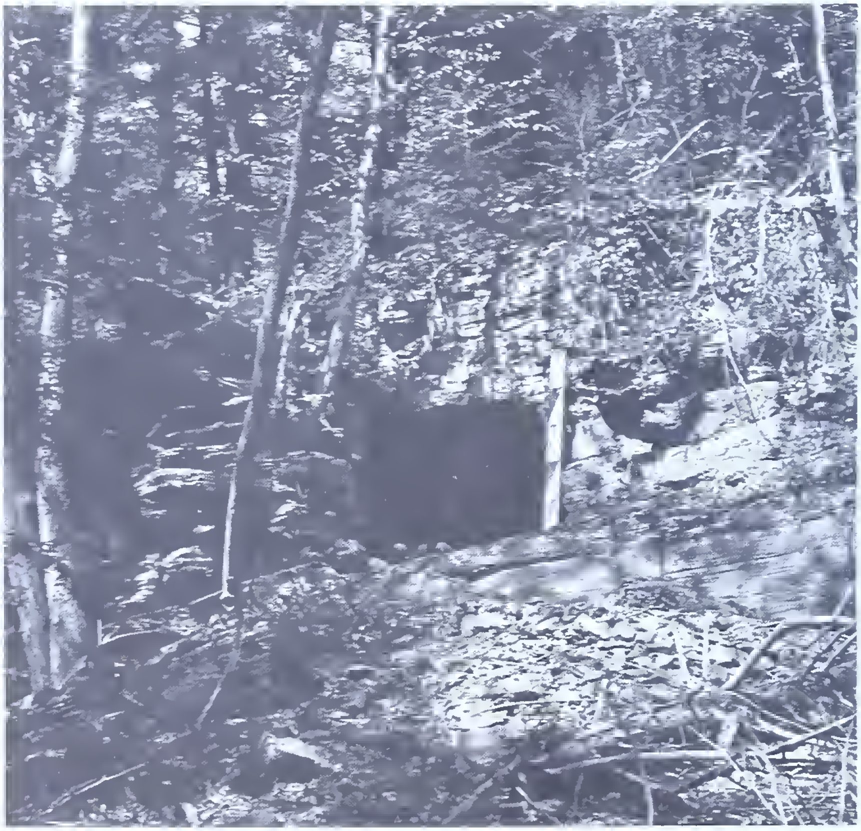

Figure 60. Southeast adit at McCauley prospect 22. The scale to the right of the adit is divided into feet and rests on planar-bedded sandstone. Photograph by W. D. Sevon.

containing abundant carbonaceous plant fragments and malachite, and having a radioactivity of 0.5±0.2 "mR/hr." The stratigraphy is described in detail in Table 41. Lateral variation is so rapid that this section, measured at the southeast face, is somewhat different from that exposed at the northwest face, a mere 1.55 m (5 ft) away. This lateral variation also helps explain the apparent difference in uranium content between the two channel samples collected from this same horizon in the southeast adit (compare samples MHK 734 and 735, Appendix 3).

A 13-cm- (5-in.-) long and 1-cm- (0.4-in.-) thick carbonaceous limb with abundant malachite staining occurs 3.5 m (12 ft) southeast of the center of the southeast adit. The radioactivity on contact is 1 to 3 "mR/hr" for almost 1 m (3 ft) along strike. Within 5.5 m (18 ft) southeast of the southeast adit, the reduced zone and uranium mineralization disappear. This yields a total length of about 25 m (82 ft) of discontinuous uranium-copper mineralization, the richest uranium mineralization occurring toward the southeast end.

McCauley prospect 22 is in the lower part of the Catskill Formation, less than 200 m (650 ft) above the base (Sevon and others, 1978). This places it less than 50 m (165 ft) above the top of the uppermost known marine beds of the lower Catskill marine transgression noted by Mahar (1978). The predominance of shales and siltstones in the lower portion of the Catskill Formation seems unfavorable for the reconcentration of the uranium into larger deposits.

Table 41. ***Stratigraphic Section of Catskill Formation Rocks at McCauley Prospect 22***

Exposure is on the southeast side of the entrance to the southeast adit, 2.45 km (1.52 mi) northeast of Tivoli.

Thickness (cm)	Radioactivity ("mR/hr" ±0.02)	Lithologic description
>200	.03	Grayish-red (5R4/2) to dark-reddish-brown (10R3/4), fine-grained sandstone.
50	.05	Medium-gray (N5), fine-grained sandstone with interbedded 1-mm- to 1-cm-thick oxidized laminae.
35	.5±.2	Medium-gray (N5), fine-grained sandstone containing carbonaceous plant fragments and malachite, especially near the base, where it is thinner bedded and contains more plant fragments.
30	.07 to .2 max.	Medium-gray (N5) to medium-dark-gray (N4) calcareous breccia containing numerous reddish shale clasts. Abundant malachite near the top. (May be replaced by dark-gray (N4) siltstone in the adit on the northwest side.)
>90	.04	Grayish-red (5R4/2), thin-bedded, fine-grained sandstone.

SONESTOWN NOSE CLUSTER A

McCauley Prospect 29

1. LOCATION:

   (a) McCauley prospect 29 is located on the north side of the Sonestown-Nordmont road, 0.33 km (0.20 mi) east of its intersection with old U.S. Route 220; the elevation at the intersection is 980 ft (299 m). The prospect is 0.33 km (0.20 mi) northeast of the confluence of Big Run and Muncy Creek. The best mineralization is 1.9 m (6.2 ft) above road level at a point 16 m (52 ft) east of highway survey marker 0/10. Two reduced zones were included in the Klemic (1962) locality 13 occurrence prior to road widening between 1962 and 1978. The upper of these reduced zones projects onto the Sonestown-Nordmont road at highway survey marker 0/20, which is approximately 275 m (900 ft) east of McCauley prospect 29 and 24 m (79 ft) higher in elevation. The lower reduced zone at Klemic locality 13 is best exposed 50 m (165 ft) west of the upper one at a point 4 m (13 ft) lower in elevation.

	McCauley prospect 29	Klemic locality 13, upper zone exposure	Klemic locality 13, lower zone exposure
(b) Latitude:	41°21′26″N	41°21′23″N	41°21′24″N
Longitude:	76°33′01″W	76°32′49″W	76°32′50″W

2. ASSAYS: A 45-cm (18-in.) channel sample of moderately clean sandstone (Figure 61) from one bed, which had an average radioactivity of

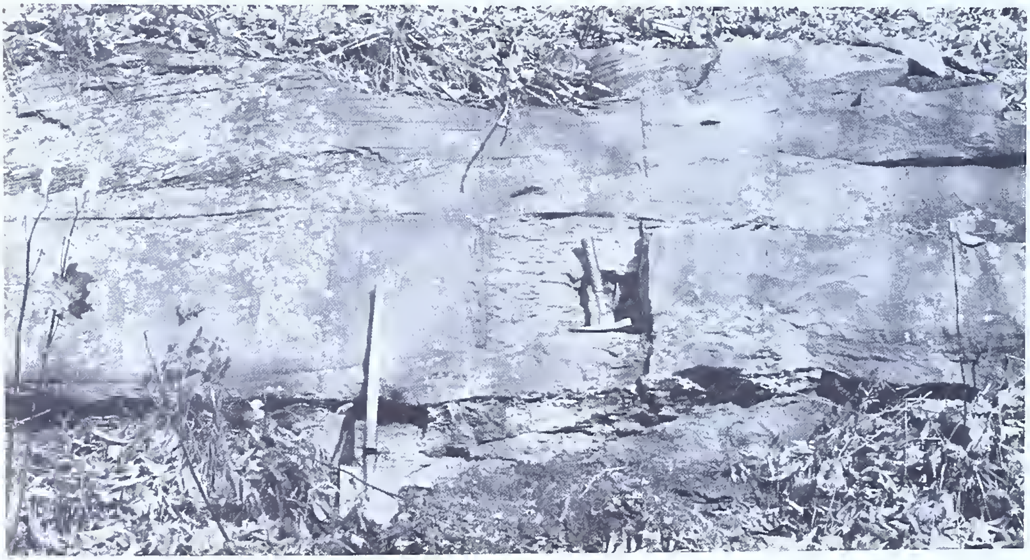

Figure 61. Cut for channel sample MHK 740 at McCauley prospect 29. The sample consists of 45 cm (18 in.) of moderately clean sandstone and contains only 10 ppm U_3O_8 and 145 ppm copper near a carbonaceous limb section that had a radioactivity of 8 "mR/hr" in the same bed.

0.03 "mR/hr," contains 10 ppm U_3O_8 and 145 ppm copper. This is astonishing because, less than 10 cm (4 in.) away, a mineralized limb section in the same bed, which had a radioactivity of 8 "mR/hr," was coated with copious copper and uranium secondary mineral ochres. See sample MHK 740, Appendix 3.

3. MINERALOGY:

Limb section

(a) Major: Malachite, chrysocolla.
(b) Minor: Kasolite as bright-yellow microspherules; covellite as partial replacements of digenite; brochantite; unidentified glassy, pistachio-green mineral.
(c) Trace: Azurite as rare microcrystals; barite in shrinkage cracks in vitreous carbonaceous matter; posnjakite and langite as blue, pearly flakes; metazeunerite–meta-uranospinite as pale-yellow-green powdery coating; and unidentified light-tan, rhombohedral microcrystals insoluble in concentrated hydrochloric acid.

Calcareous sandstone and breccia

(a) Major: Malachite.
(b) Minor: "Chalcocite" as partial replacements of carbonaceous plant fragments.
(c) Trace: Azurite; brochantite; barite; "apatite" as phosphatic fish remains; and chalcophyllite as bluish-green six-sided microcrystals associated with "chalcocite" 8.85 m (29.0 ft) east of the reference site.

Table 42. *Stratigraphic Section of Catskill Formation Rocks at McCauley Prospect 29*

Exposure is an outcrop at the reference site on the north side of the Sonestown-Nordmont road.

Thickness (cm)	Radioactivity ("mR/hr")	Lithologic description
>100	.025	Medium-gray (N5) to dark-greenish-gray (5GY4/1), medium-grained, thin- to thick-bedded crossbedded sandstone. This unit is micaceous and calcareous in the basal portion.
14	.10 .30 max.	Between medium gray (N5) and light brownish gray (5YR6/1). Weathered calcareous breccia containing a small lens of medium-grained calcareous sandstone. This unit contains abundant malachite in, on, and near carbonaceous plant fragments, and minor azurite and phosphatic fish remains. Abundant grayish-red (5R4/2) shale chips occur at the base of the unit. This unit is represented by calcareous sandstone on its continuation to the east.
>100	.03	Grayish-red (5R4/2) interbedded shale and micaceous siltstone which is calcareous at the top. Laminae of dark-greenish-gray (5GY4/1) shale and siltstone occur near the top of this unit.

4. GEOLOGIC DESCRIPTION: Highly erratic copper and uranium mineralization is associated with a few fossil plant fragments in a $\geq$ 1.1-m- (3.6-ft-) thick reduced sandstone lens containing minor calcareous breccia. The stratigraphic section exposed at the occurrence, located on the order of 300 m (1,000 ft) beneath the top of the Catskill Formation, is described in Table 42. Bedding at the occurrence is nearly horizontal, and joints trend about N30°E and dip vertically.

   Two mineralized limb sections oriented approximately N64°E and approximately N87°E were observed in the gray sandstone unit 8.85 m (29.0 ft) east of the reference site. Two smaller twigs (approximately 2 by 10 cm, or 0.8 by 4 in.) at the base of the sandstone bed had radioactivities on contact of 0.15 and 0.2 "mR/hr." One larger limb section (5 by 20 cm, or 2 by 8 in.), located 2.3 m (7.5 ft) east of the reference site, yielded 2.0 "mR/hr" on a cross section and up to 8.8 "mR/hr" along the long axis after excavation. This limb was located 25 cm (10 in.) above the base of the 45-cm- (18-in.-) thick massive bed of sandstone at the base of the sandstone unit (Table 42) at a point where the underlying calcareous breccia thinned to almost nothing. The most curious aspect of this carbonaceous limb is the presence of an approximately 1 cm (0.4 in.) thick halo of reddish-maroon oxidation in the otherwise reduced, grayish massive bed of sandstone.

Mosey Glen Uranium-Copper Occurrence

1. LOCATION:
   (a) The occurrence is located 1.7 m (5.6 ft) above the level of Mosey Run on the north side of the glen, where it trends N85°W. The glen itself contains small waterfalls and is more pronounced than shown on the topographic map (Figure 62). The occurrence is at an elevation of 335 ± 3 m (1,100 ± 10 ft), 0.42 km (0.26 mi) east-northeast of the confluence of Mosey Run with Big Run, 0.68 km (0.42 mi) northeast of the intersection of Nordmont Road with old U.S. Route 220 in Sonestown, and 0.10 km (0.06 mi) west-northwest of where Mosey Run passes under old U.S. Route 220, Davidson Township, Sullivan County. There is a cabin on the south side of Mosey Run, not shown on the topographic map, located S64°W and at an inclination of + 12 degrees relative to the occurrence.
   (b) Latitude: 41°21′45″N
   Longitude: 76°32′56″W
2. ASSAYS: A 31-cm (12-in.) channel sample of gray shale and siltstone contains 625 ppm U_3O_8, 3,200 ppm copper, and 520 ppm arsenic. See sample PRS–9, Appendix 3.
3. MINERALOGY:
   (a) Major: None.
   (b) Minor: Malachite.
   (c) Trace: "Chalcocite" as blebs up to 3 mm, and as a replacement of a limb; chrysocolla. All in gray shale and siltstone containing grayish-red laminae.

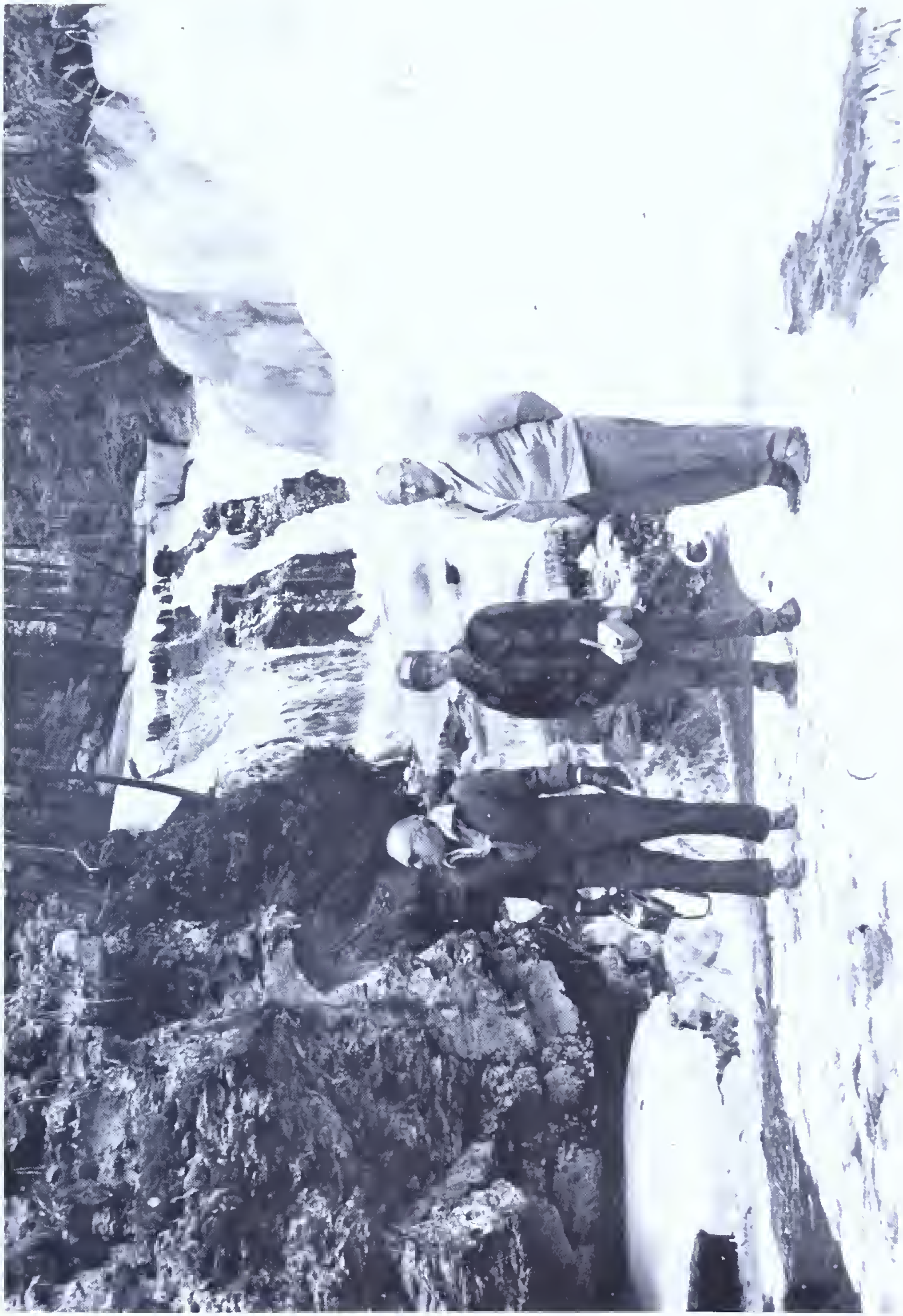

Figure 62. Mosey Glen uranium-copper occurrence, and (left to right) A. Z. Gill, J. V. Jordan, and J. Fredock. This is the first occurrence found by Gill, circa 1956.

4. GEOLOGIC DESCRIPTION: The occurrence consists of an unprospected, natural outcrop which has a 4-m- (13-ft-) long reduced zone yielding $\geq$ 200 cps with the scintillometer. A radiometric assay at the channel-sample site yielded 400 ppm eU, but this is atypically rich for the overall zone. The average radioactivity at this site is 0.2 ''mR/hr,'' and the maximum is 0.5 ''mR/hr.'' The 31 cm (12 in.) of assayed shale and siltstone was selected by using a cutoff of 0.1 ''mR/hr'' and contains oxidized laminae. The stratigraphy is described in Table 43. One 14-cm- (5.5-in.-) long by approximately 1 cm (0.4 in.) thick, malachite-encrusted ''chalcocite'' replacement of a plant limb was observed 0.5 m (1.6 ft) west of the channel-sample site. The maximum radioactivity observed on this plant fragment is 0.3 ''mR/hr.''

Table 43. *Stratigraphic Section of Catskill Formation Rocks at the Mosey Glen Uranium-Copper Occurrence*

Exposure is on the north side of Mosey Glen where it trends N85°W, 0.45 m (1.5 ft) east of the malachite-encrusted fossil plant limb.

Thickness (cm)	Radioactivity (''mR/hr'')	Lithologic description
>200	.03	Grayish-red (5R4/2), undulating, laminated to thin-bedded, interbedded shale and mudstone. Unit is gradational to medium dark gray (N4) near the base.
31	.20	Medium-dark-gray (N4) to grayish-brown (5YR3/2), undulating, laminated to thin-bedded, interbedded shale and siltstone containing grayish-red laminae and blotches, malachite, and circular grains of ''chalcocite'' up to 3 mm. This assayed unit was defined by using a 0.10-''mR/hr'' cutoff at the top and bottom.
>150	.03	Grayish-red (5R4/2), laminated to medium-bedded, interbedded shale, mudstone, siltstone, and fine-grained sandstone. The unit is slightly crossbedded.

A small pod of reduced, greenish-gray siltstone containing one ''chalcocite'' and covellite(?) replacement of a plant limb occurs 22.5 m (74 ft) upstream, just above water level. This small underhang yields 1,200 cps. The median strike of bedding in the creek is N32°W and the median dip is 5°SW, but there is moderate variation in the bedding attitude.

In general, the occurrence resembles the Avery Brothers uranium adit and the Shultz copper adit, both of which contain ''chalcocite'' in planar-bedded, partly oxidized, fine-grained sediments rather low in the Catskill Formation. The occurrence, the first found by Tony Gill during the mid- to late 1950's, is of interest because it helps demonstrate the presence of uranium at three different horizons in the Sonestown Nose area.

SONESTOWN NOSE CLUSTER B

Sonestown Nose Uranium Trench of Gill-Jordan

1. LOCATION:

(a) The trench is located on the T. Peterman tract at the break in slope on the north side of a ridge bounded on three sides by Mosey Run, Big Run, and Muncy Creek. This ridge, located approximately 0.8 km (0.50 mi) northeast of Sonestown, has been informally named the "Sonestown Nose" in this report. The trench is 0.58 km (0.36 mi) northeast of the junction of old U.S. Route 220 with the Sonestown-Nordmont road, at an approximate elevation of 375 m (1,230 ft). To reach the main, upper bench from new U.S. Route 220 highway survey marker 3/10, follow an uphill, S70°W-trending drainage cut/road up 8.5 m (28 ft) in elevation from the marker to where a trail enters the woods, and proceed an additional 9.5 m (31 ft) higher in elevation toward the south-southwest. This brings one to the extreme southeast end of the upper bench, the reference point for this description (Figure 63). The southeast end of the trench is 0.50 km (0.31 mi) east-southeast of the confluence of Big Run and Mosey Run, Davidson Township, Sullivan County.

	Reference point (southeast end of trench)
(b) Latitude:	41°21′34″N
Longitude:	76°32′51″W

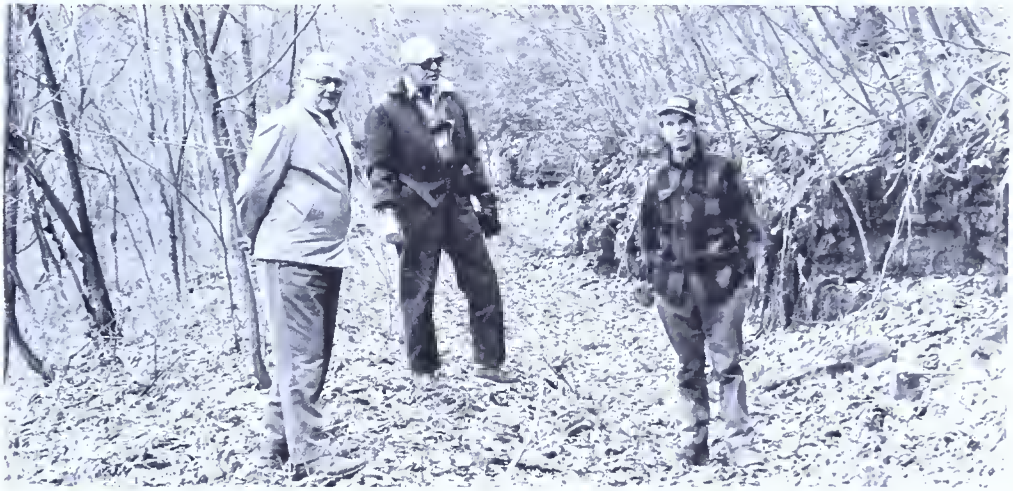

Figure 63. J. Fredock, A. Z. Gill, and J. V. Jordan (left to right) on the upper bench of the Sonestown Nose uranium trench of Gill-Jordan as it appeared in 1980, looking to the southeast. The reference point is the far face between Gill and Jordan.

2. ASSAYS: A 27-cm (11-in.) channel sample of gray, fine-grained sandstone containing calcareous breccia from the southeast channel-sample site (21.5 m (70.5 ft) northwest of the reference point) has about 250 ppm U_3O_8, 1.65 percent copper, 0.50 troy oz/ton silver, 470 ppm arsenic, 845 ppm lead, and 500 ppm vanadium. See sample MHK 742, Appendix 3.

   A 27-cm (11-in.) channel sample of calcareous breccia and minor calcareous sandstone from the northwest channel-sample site (68.5 m (225 ft) northwest of the reference point) contains about 311 ppm U_3O_8, 6,500 ppm copper, 900 ppm arsenic, 4,200 ppm lead, and 700 ppm vanadium. A 60-cm (24-in.) channel sample of the underlying gray sandstone from the northwest channel-sample site contains 29 ppm U_3O_8, 1,450 ppm copper, 40 ppm arsenic, 340 ppm lead, and approximately 365 ppm vanadium.[1] See samples MHK 747 and 746, Appendix 3.
3. MINERALOGY[2]:

   Mini adit (7.5 m (25 ft) northwest of reference point)
   - (a) Major: Malachite.
   - (b) Minor: Digenite and covellite replacements of carbonaceous plant fragments.
   - (c) Trace: Langite and/or posnjakite; unidentified yellow secondary uranium mineral; brochantite as microcrystalline crusts; unidentified greenish-yellow, tabular microcrystals; and unidentified light-gray to green radiated fibers.

   Southeast channel-sample site (21.5 m (70.5 ft) northwest of reference point)
   - (a) Major: Malachite associated with carbonaceous plant fragments in calcareous sandstone.
   - (b) Minor: None.
   - (c) Trace: Barite as clear, micaceous, colorless microcrystals associated with malachite on calcareous breccia; chrysocolla as crusts of green micro-botryoids; azurite; and kasolite(?) as golden crystalline crusts.

   Northwest channel-sample site (68.5 m (225 ft) northwest of reference point
   - (a) Major: Malachite on micaceous bedding partings.
   - (b) Minor: None.
   - (c) Trace: "Chalcocite" and chalcopyrite richly disseminated in upper calcareous breccia.

   Site 80 m (262 ft) northwest of reference point
   - (a) Major: None.
   - (b) Minor: Chalcopyrite disseminated in calcareous breccia; tyuyamunite-metatyuyamunite as bright-greenish-yellow, finely crystalline coatings on sandstone on and/or near black manganese(?) stains.

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[1] Radiometric field assay yields 300 ppm eU for the upper, 27-cm (11-in.) unit and 400 ppm eU for the lower, 60-cm (24-in.) unit.

[2] All of the listed occurrences are on the main, upper bench; measurements were made from the reference point at the southeast end.

(c) Trace: Cerussite as clear, colorless microcrystal groups; "apatite" as phosphatic fish remains; uraninite as black, waxy replacements of carbonaceous plant fragments having a subconchoidal fracture; malachite; kasolite as dull-golden coatings; widenmannite as pale-greenish-white coatings around carbonaceous plant fragments; opal (variety hyalite), some of which fluoresces green; roscoelite(?) as dark-brown micaceous flakes near tyuyamunite; rare linarite(?); beudantite(?) as dull-golden botryoidal crust; mottramite(?) as dull, yellow-tan coating; nonfluorescent autunite group mineral as bright-yellow unknown in "apatite"; francevillite as bright-canary-yellow coating; and mimetite(?) associated with beudantite(?).

4. GEOLOGIC DESCRIPTION: The Gill-Jordan prospect on the Sonestown Nose consists primarily of an elongated, trenchlike open cut that trends approximately N75°W, but has a gentle bow toward the south in the middle (Figure 64). The length of the trench, which was at one time continuous, is 87 m (285 ft). The average highwall on the south side of the trench is 1.7 m (5.6 ft) high and the maximum height occurs at the southeast end, where it is 2.5 m (8.2 ft). The width of this main, upper bench is 4.5 ± 1 m (15 ± 3 ft). A less distinct, lower bench is 2 ± 0.3 m (7 ± 1 ft) high and 5 ± 2 m (16 ± 7 ft) wide. It is irregular in geometry, especially at the northwest end. In addition to the two benches, there are several meter- (3-ft) sized excavations on the hill above the main, upper bench.

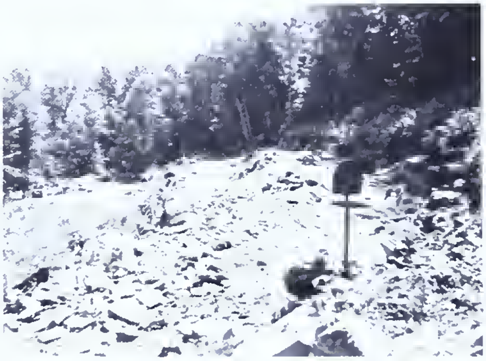

Figure 64. View looking southeast from the west end of the Sonestown Nose uranium trench of Gill-Jordan as it appeared during the late 1950's. Photograph by A. Z. Gill.

Several measurements of the attitude of bedding in the upper bench yielded a median strike of N29°W and a median dip of 7°SW. Pronounced, vertical joint surfaces trending N24°E and N34°E were observed.

Both the local stratigraphy and mineralization are highly variable along the exposure in the upper trench. The variation in mineralization along strike is evident in Table 44, a summary of radiometric measurements taken at 5-m (16.4-ft) intervals. The stratigraphic variability along

Table 44. *Summary of Radiometric Measurements Taken along the Sonestown Nose Uranium Trench of Gill-Jordan*

Measurements were taken along the south highwall of the trench, on the upper level.

Location[1]		Thickness (0.1-"mR/hr" cutoff)		Maximum radioactivity observed	Comments
(m)	(ft)	(cm)	(in.)	("mR/hr")	
5	16.4			.05	
7.5	24.6	40	16	3.0	In 0.9- by 1.1- by 0.5-m- (3.0- by 3.6- by 1.6-ft-) mini-adit in crossbedded, "maroon" sandstone and siltstone containing carbonaceous plant fragments partly replaced by "chalcocite" and bearing abundant malachite. Calcareous breccia at base is lean.
10	32.8	10	4	.7	Largely maroon sandstone containing carbonaceous plant fragments and malachite.
15	49.2	—	—	.05	
20	65.6	—	—	.06	Calcareous breccia beneath gray, micaceous sandstone.
21.5	70.5	40	16	1.4	From the top down: "maroon" sandstone; calcareous breccia containing abundant malachite and lenses of "maroon" and gray sandstone containing abundant carbonaceous plant fragments and malachite; and gray sandstone (Table 45).
25	82	—	—	.05	
30	98	—	—	.04	
35	115	—	—	.04	
40	131	—	—	.04	
45	148	—	—	.05	

46.5	153	27	11	.32	Alcove in which there is 27 cm (11 in.) of gray, micaceous sandstone that is locally "maroon" where it contains carbonaceous plant fragments, malachite, and secondary uranium ochres (?).
50	164	—	—	.04	
55	180	—	—	.03	
60	197	—	—	.03	
65	213	32	13	.2	Gray sandstone below calcareous breccia.
68.5	225	30	12	.6	Calcareous breccia containing lenses of "maroon" sandstone, carbonaceous plant fragments, and malachite.
—	—	64	25	.15	Gray sandstone containing small lenses of calcareous breccia (Table 46.)
70	230	17	7	.25	Maroon to gray sandstone containing lenses of calcareous breccia.
75	246	20	8	.3	Calcareous breccia.
80	262	~55	~22	8.5	From the top down: 45 cm (18 in.) of gray sandstone; approximately 5 cm (2 in.) of coarse, carbonaceous plant fragments that have yellow secondary uranium ochres in proximity to them; and 9 cm (3.5 in.) of interbedded calcareous breccia and gray sandstone (Table 47).
85	279	63	25	.5	From the top down: 15 cm (6 in.) of gray sandstone; 32 cm (13 in.) of calcareous breccia containing lenses of gray sandstone; and 16 cm (6 in.) of gray sandstone.

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[1] Locations are relative to the reference point at the southeast end of the trench.

Table 45. *Stratigraphic Section of Catskill Formation Rocks 21.5 m (70.5 ft) Northwest of the Reference Point at the Sonestown Nose Uranium Trench of Gill-Jordon*

Reference point is at the extreme southeast end of the upper bench.

Thickness (cm)	Radioactivity ("mR/hr")	Lithologic description
22	.05	Grayish-red-purple (5RP4/2), medium-grained sandstone.
23	.2 1.4 max.	Grayish-red-purple (5RP4/2) to dark-greenish-gray (5GY4/1), fine-grained sandstone. This assayed unit contains carbonaceous plant fragments, malachite, and zones of calcareous breccia immediately along strike.
8	.09	Grayish-red-purple (5RP4/2), fine-grained sandstone. The top 4 cm of this unit is included in the 27-cm-thick assayed sample.
>48	.07	Medium-dark-gray (N4), fine-grained sandstone at the top, grading to grayish-red-purple (5RP4/2), fine-grained sandstone near the bottom. The unit is very micaceous on bedding surfaces.

Table 46. *Stratigraphic Section of Catskill Formation Rocks 68.5 m (225 ft) Northwest of the Reference Point at the Sonestown Nose Uranium Trench of Gill-Jordon*

Reference point is at the extreme southeast end of the upper bench.

Thickness (cm)	Radioactivity ("mR/hr")	Lithologic description
>40	.05	Brownish-gray (5YR4/1) to dusky-yellowish-brown (10YR2/2), medium-grained, micaceous sandstone.
27	.5	Medium-gray (N5) calcareous breccia containing carbonaceous plant fragments and abundant malachite. This assayed unit has lenses of grayish-red-purple (5RP4/2), fine-grained sandstone with disseminated "chalcocite."
25	.25	Medium-gray (N5), fine-grained sandstone containing trace malachite, and several approximately 1.0 cm thick laminae of grayish-red-purple (5RP4/2), fine-grained sandstone. This unit and the two reduced units below make up the 60-cm-thick assayed sample.
12	.15 .6 max.	Medium-gray (N5) calcareous breccia containing trace malachite and "chalcocite."
25	.06	Medium-gray (N5), fine-grained sandstone which is extremely micaceous on bedding surfaces and contains trace malachite.
>13	.05	Grayish-red-purple (5RP4/2), fine-grained sandstone which is highly micaceous on bedding surfaces.

Table 47. *Stratigraphic Section of Catskill Formation Rocks 80 m (262 ft) Northwest of the Reference Point at the Sonestown Nose Uranium Trench of Gill-Jordan*

Reference point is at the extreme southeast end of the upper bench.

Thickness (cm)	Radioactivity ("mR/hr")	Lithologic description
45	~.1	Dark-greenish-gray (5G4/1) to medium-dark-gray (N4), fine- to medium-grained sandstone with light-brownish-gray (5YR6/1) calcareous zones containing sparse disseminated chalcopyrite. The unit includes dark-greenish-gray shale chips and phosphatic fish remains.
~5	1.5 8.5 max.	Gray, fine- to medium-grained sandstone containing abundant large carbonaceous plant fragments, minor tyuyamunite-metatyuyamunite, and trace kasolite. The unit was probably pyritic in part.
9	.05 .2 max.	Medium-gray (N5) to brownish-gray (5YR4/1) calcareous breccia interbedded with olive-gray (5Y4/1), fine- to medium-grained sandstone which has a grayish-brown (5YR3/2) weathered surface. The unit contains trace disseminated chalcopyrite in the brownish-gray calcareous breccia.

strike is evident from the stratigraphic descriptions for the 21.5-m (southeast channel sample), 68.5-m (northwest channel samples), and 80-m (richly mineralized) sites (Tables 45 to 47). The relative locations of the calcareous breccia horizons, which are below the reduced sandstone in typical occurrences, are anomalous and vary over short distances along strike. In general, the most intense mineralization occurs near the two ends of the trench (7.5-m site and especially the 80-m site). The middle section is lean. At the 7.5-m site, one 0.8- by 12-cm (0.3- by 5-in.) carbonaceous plant fragment, partly replaced by digenite and covellite, yields a maximum radioactivity of 3.0 "mR/hr." Disseminated "chalcocite" is moderately abundant in the sandstone above this fragment. The maximum radioactivity observed at the 80-m site was first recorded as 1.9 "mR/hr," but after partial excavation this increased to 8.5 "mR/hr." After removal of the specimens that had visible uranium-vanadium-lead-copper mineralization, an activity of 4 "mR/hr" remained.[1] Because this site contains the only appreciable concentration of vanadium in the project area, it deserves further attention to determine the primary form of the vanadium and its relation to uranium-vanadium occurrences elsewhere in Pennsylvania.

In addition to minor copper-uranium at this horizon to the northwest and south (Plate 1), a moderate amount of barite was observed at what appears to be the same horizon in the roadcut to the east, approximately

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[1] This yielded a radiometric field assay of 400 ppm eU.

7 m (23 ft) above the level of new U.S. Route 220 at a point about 20 m (65 ft) southwest of highway marker 3/20. The barite occurs as salmon-colored and white, coarsely crystalline masses associated with white calcite and drusy quartz in partly crosscutting veins. The observed barite occurs in minor structures that are assumed to be Alleghanian in age, but the barium probably has not been remobilized very far.

The trench was excavated during the late 1950's by the Gill Mining Corporation of Muncy Valley, Pennsylvania. Anthony Z. Gill was president of this corporation, but it is likely that most of the actual mining was accomplished by the vice-president, John V. Jordan. The 200-m-(650-ft-) long, freshly stripped area is clearly visible on 1959 aerial photographs. This prospect represents the largest known effort in the project area during the uranium exploration boom of the late 1950's. The excavation did not proceed without difficulties (Figure 65). The securities-offering circular (1958) contained the following description of the property:

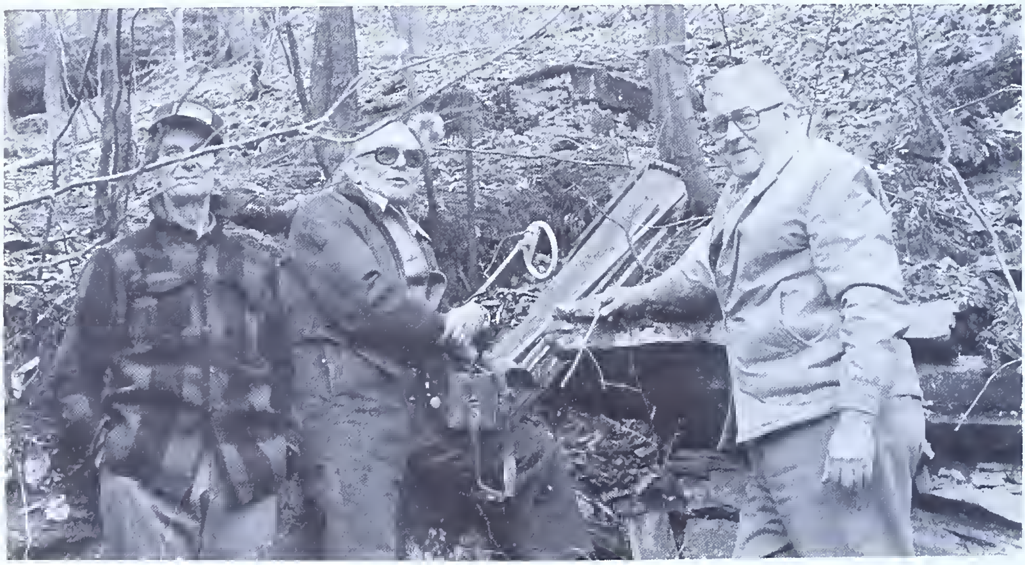

Figure 65. J. V. Jordan, A. Z. Gill, and J. Fredock (left to right) at the southeast end of the Sonestown Nose uranium trench of Gill-Jordan. The jammed drill rod above Gill's hand and unused core box to his left testify to difficulties encountered by prospectors.

> The corporation is now conducting its operation at the Sonestown site. . . . This encompasses an area of approximately 100 acres [40 ha]. The timber has been cleared from the area to be mined and the outcrop of uranium deposits has been exposed by blasting procedures over an area about one-fifth of a mile [0.3 km] long.
>
> An office cabin [Figure 66] has been constructed at the site, as well as structure for storage of dynamite and blasting caps. The samples shown in the reports attached hereto were taken from this location.
>
> No drilling has been undertaken as yet. Test borings will be made within the next three months to determine the nature and extent of the ore. A roadway to the area has

Figure 66. J. Fredock, A. Z. Gill, and J. V. Jordan (left to right) in front of the office of the Gill Mining Corporation near Mosey Glen.

> already been made and the timber cleared, and all is in readiness for the drilling operations. . . .
>
> For the next several months, our plans include the drilling of approximately 100 holes at the Sonestown location averaging 50 feet [15 m] in depth at an average cost of $2.00 per foot.

Based on limited data and the optimistic assumptions of a 25-m- (82-ft-) long (62 to 87 m, or 203 to 285 ft, from the reference point) "orebody" (Figure 67) that is 0.5 m (1.6 ft) thick, continues 25 m (82 ft) to the south, and contains 100 ppm U_3O_8, there would be 8 kg (17.6 lb) of uranium present in 80 metric tons (88 tons) of rock. Although this is well below the present volume, thickness, and lower grade limits worthy of economic consideration, it suggests the presence of more uranium here than at most prospects and occurrences in the district.

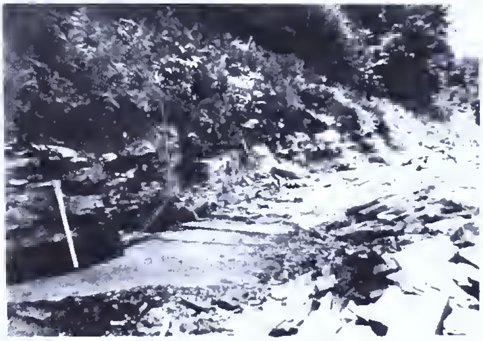

Figure 67. View of the northwest end of the Sonestown Nose uranium trench of Gill-Jordan, looking west, as it appeared during the late 1950's. Gill reported "90 feet [about 30 m] of carbonaceous copper-uranium" to the right of the pick. The view includes the 68.5-m and 80-m sites of the present report. Photograph by A. Z. Gill.

Middle Catskill Reduced Zone Uranium-Copper Occurrence

1. LOCATION:
   (a) The occurrence is located on the Russell Quava property on the southeast side of a secondary road on the northwest side of North Mountain at an elevation of 356 m (1,170 ft). The occurrence projects onto the road at a point (reference site) which is 196 ± 10 m (640 ± 33 ft) north of the hairpin turn, 0.43 km (0.27 mi) southeast of the covered bridge over Muncy Creek, and 1.20 km (0.75 mi) south-southeast of the confluence of Big Run and Muncy Creek, in Sonestown, Davidson Township, Sullivan County.
   (b) Latitude: 41°20′41″N
   Longitude: 76°33′02″W
2. ASSAYS: A 33-cm (13-in.) channel sample of gray calcareous breccia contains 56 ppm U_3O_8 and 305 ppm copper. A 5-cm (2-in.) channel sample of the medium-grained gray sandstone (which has a remarkable moderate-reddish-brown (10R4/6) weathering rind, as shown on color photograph 31) contains 9 ppm U_3O_8 and 350 ppm copper. See samples MHK 777 and 778, Appendix 3.
3. MINERALOGY:
   (a) Major: None.
   (b) Minor: Unidentified moderate-reddish-brown weathering rind, especially on cupriferous sandstone beds.
   (c) Trace: Chalcopyrite as minute disseminated grains with highly serrated rims in sandstone, and in and/or near malachite in calcareous breccia.
4. GEOLOGIC DESCRIPTION: The occurrence consists of three levels of large, natural outcrops, but the observed mineralization is confined to the basal series of outcrops. From the reference site (where the base of the reduced zone projects onto the road) south, the total length of nearly continuous outcrop containing calcareous breccia that yields greater than or equal to approximately 200 cps is 50 m (165 ft). Typically, this zone of reduced calcareous breccia yields 300 ± 100 cps with the scintillometer and is 15 ± 5 cm (6 ± 2 in.) thick.

   Where best exposed near the north end, the mineralized calcareous breccia is 1.5 m (5 ft) above the base of the channel and is only 13 ± 2 cm (5 ± 0.8 in.) thick where richest. The maximum radioactivity, 0.5 "mR/hr," is extremely localized, a 0.2 "mR/hr" cutoff yielding a strike length of only 35 cm (14 in.). Using a cutoff of 500 cps, the zone is 3.3 m (11 ft) long. A field radiometric assay along this richer portion yielded 330 ppm eU, but these readings were obtained on thin calcareous breccia lenses that were weathered back into the face about 5 to 10 cm (2 to 4 in.). More typical radiometric assays, such as those taken 27 m (89 ft) to the south, where the channel samples were cut through more massive calcareous breccia, yielded 100 ppm eU along the overall calcareous breccia zone.

   At the north end of the exposure, where the mineralized horizon projects onto the road, the calcareous breccia becomes progressively more silty and at the extreme end is transitional to sandstone. This sandstone weathers to a rusty color, suggesting the presence of pyrite, and contains very abundant coaly plant fragments which are not especially radioactive compared to the calcareous breccia at the same horizon a few meters to the south.

In the vicinity of the channel-sample site, 27 m (89 ft) south of the reference point, the base of the mineralized breccia is ≥ 0.9 m (3.0 ft) above the base of the reduced zone. Here, the calcareous breccia is typically 33 cm (13 in.) thick and yields a typical radioactivity of 380 cps and a radiometric assay of 80 ppm eU. A 5-cm- (2-in.-) thick, fine-

Table 48. ***Stratigraphic Section of Catskill Formation Rocks at the Middle Catskill Reduced Zone Uranium-Copper Occurrence***

Exposure is 27 m (89 ft) south of where the base of the reduced zone projects onto the secondary road (reference point).

Thickness (cm)	Radioactivity ("mR/hr")	Lithologic description
>200	.03	Medium-light-gray (N6) to medium-gray (N5), fine- to medium-grained, micaceous, thin- to medium-bedded, crossbedded sandstone which contains lenses of gray calcareous breccia. The bottom half of this unit exhibits an approximately moderate reddish brown (10R4/6) weathering rind.
30	.04	Gray calcareous breccia.
71	.04	Medium-gray (N5), fine- to medium-grained, laminated to thin-bedded sandstone which exhibits undulations and internal crossbedding. The unit is micaceous, contains abundant carbonaceous plant fragments near the top, has an approximately moderate reddish brown (10R4/6) weathering rind, and is highly friable in part. The assayed bottom 5 cm contains disseminated chalcopyrite grains.
59	.03	Medium-gray (N5), medium-grained, thin- to medium-bedded, crossbedded sandstone which is medium dark gray (N4) and very micaceous near the bottom.
33	.07	Dark-greenish-gray (5G4/1) calcareous breccia which has abundant dark-greenish-gray (5G4/1) shale chips at the base. This assayed unit contains sparse chalcopyrite and malachite associated with shale chips.
>90	.05	Medium-gray (N5), medium-grained, micaceous, thin- to medium-bedded, crossbedded sandstone. The top approximately 5 cm of this unit is between medium gray (N5) and brownish gray (5YR4/1), is fine grained, and contains disseminated chalcopyrite grains. This unit bears a weathering rind approximately 0.5 to 1.0 cm thick. From internal to external, the weathering colors are dark gray to tan to approximately moderate reddish brown (10R4/6).

grained sandstone immediately beneath the calcareous breccia contains disseminated chalcopyrite, especially in an approximately 2 cm (0.8 in.) thick layer of transitional colors. This chalcopyrite-bearing sandstone weathers to moderate reddish brown (10R4/6). More than 5 cm (2 in.) beneath the calcareous breccia, the sandstone has a normal gray color. Some of the other gray sandstone beds above the calcareous breccia have a similar rusty-orange weathering rind, but contain only very sparse, disseminated chalcopyrite grains approximately 0.5 mm in size. The stratigraphy at the channel-sample site is described in Table 48. The mineralogic nature of this very thin, rusty-orange weathering rind has not been determined.

The subtle difference between this rusty-orange color and similar colors developed on pyritic sandstones in the region (especially in a zone at an approximate elevation of 470 m (1,550 ft) north and east of the Sheets ''coal mine'' and approximately 0.3 km (0.2 mi) south of this occurrence on the Quava property) has led to the finding of a few reduced sandstones that contain trace copper (such as at the Marquardt copper occurrence, p. 223). Under favorable lighting conditions this coloration might prove to be a useful prospecting tool for those energetic enough to obtain unweathered hand samples in search of trace chalcopyrite.

Two levels of outcrops above the basal outcrops described in the preceding paragraphs reveal that this complex, reduced channel is 13.5 m (44 ft) thick. Of this, the lower 10 m (33 ft) is all reduced and the top 3.5 m (12 ft) contains some transitional colors. The presence of Ray

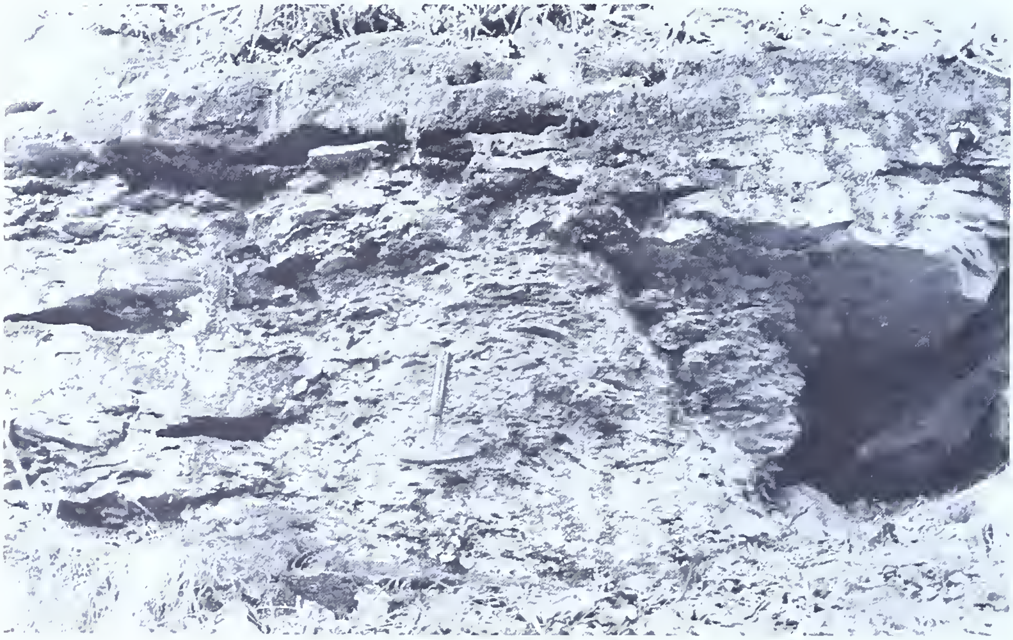

Figure 68. Thick basal "plum pudding" shale-chip rubble and malachite-bearing calcareous breccia, about 100 m (325 ft) east of the gray flagstone quarry (Plate 1).

Chico's aluminum sample tags (numbers 190 and 191) indicates that this occurrence has been known since at least September 4, 1974.

The same reduced zone has been projected 0.92 km (0.57 mi) southwest to a gray flagstone quarry at an elevation of about 366 m (1,200 ft). The extreme base of the zone, exposed about 100 m (325 ft) east of the quarry, contains malachite in basal calcareous breccia as well as basal "plum pudding" shale-chip rubble (Figure 68). The zone is also well exposed at an elevation of about 366 m (1,200 ft) just below the flat area 0.3 km (0.2 mi) southwest of this occurrence on the Quava property. Detailed examination would probably reveal minor copper-uranium occurrences in both areas.

Based on reconnaissance mapping by W. D. Sevon, the Middle Catskill Reduced Zone occurrence is about 250 m (820 ft) beneath the top of the Catskill Formation. (Sevon and others (1978) estimate that the total thickness of the Catskill Formation in the project area is about 1,070 m, or 3,500 ft). Foot-traverse reconnaissance of this horizon on the north and west sides of North Mountain is recommended.

Sonestown Nose Northwest Uranium-Copper Occurrence

1. LOCATION:
   (a) The occurrence is located on the T. Peterman property on the north side of the Sonestown Nose, 0.41 km (0.25 mi) northeast of the junction of the Sonestown-Nordmont road with old U.S. Route 220 and 0.62 km (0.38 mi) north-northeast of the confluence of Big Run and Muncy Creek (Plate 1). It is approximately 158 m (518 ft) N65°W from the northwest end of the Sonestown Nose uranium trench of Gill-Jordan, and at the same elevation, 375 m (1,230 ft).
   (b) Latitude: 41°21′38″N
   Longitude: 76°33′02″W
2. ASSAYS: A 21-cm (8-in.) channel sample of gray calcareous sandstone contains 32 ppm U_3O_8 and 300 ppm copper. See sample MHK 771, Appendix 3.
3. MINERALOGY:
   (a) Major: "Apatite" as phosphatic fish remains including complete crossopterygian scales, major in calcareous sandstone and minor in calcareous breccia.
   (b) Minor: Malachite as radiated fibrous microcrystals and coatings associated with a carbonaceous twig in calcareous breccia; also as coatings on bedding partings, in and near phosphatic fish remains, in and near carbonaceous plant fragments, and interstitial in calcareous sandstone.
   (c) Trace: "Chalcocite" associated with covellite(?) as a partial replacement of a carbonaceous twig in calcareous breccia; chalcopyrite, and "chalcocite" associated with bornite as disseminated micrograins in calcareous sandstone; and "chalcocite" richly disseminated near the contact of noncalcareous sandstone with calcareous sandstone.

4. GEOLOGIC DESCRIPTION: Although the occurrence is only exposed for a strike length of 1 m (3 ft), reduced sandstone and calcareous breccia can be traced discontinuously at this horizon for 158 m (520 ft) southeast to the Sonestown Nose uranium trench of Gill-Jordan and a substantial distance southwest to an area overlooking Sonestown. Based on scintillometer readings, the gray sandstone in this zone is leanly mineralized with uranium at several places. Also, there is a second reduced zone a few tens of meters above this one, and a third, 48.5 m (160 ft) above the first, which extends over the entire flat of the Sonestown Nose in this area (see Sonestown Nose Reduced Cap copper-uranium zone, p. 177, and the stratigraphically lower McCauley prospect 29, p. 158).

Radiometric field assays suggest 100 ppm eU in the assayed calcareous sandstone, 30 ppm in the overlying calcareous breccia, and 40 ppm in the underlying sandstone (Table 49), but the limited exposure resulted in worse geometric problems than usual with the method. A single 10-cm-(4-in.-) long carbonaceous plant fragment and associated malachite in the calcareous breccia yielded a maximum radioactivity of 0.4 "mR/hr."

In that it demonstrates substantial lateral extent of discontinuous, but similar (with respect to such features as stratigraphic order and presence of chalcopyrite in calcareous sandstone) mineralization and the stacking

Table 49. *Stratigraphic Section of Catskill Formation Rocks at the Sonestown Nose Northwest Uranium-Copper Occurrence*

Exposure is at a 1-m (3-ft) strike-length outcrop.

Thickness (cm)	Radioactivity ("mR/hr")	Lithologic description
25	.03	Predominantly grayish red (5R4/2), but also between grayish red (5R4/2) and blackish red (5R2/2). Medium-grained, micaceous, thin-bedded sandstone.
45	.03	Between greenish gray (5G6/1) and dark greenish gray (5G4/1). Calcareous breccia, which is brownish gray (5YR4/1) near the top and contains abundant dark-greenish-gray (5GY4/1) shale chips near the bottom. Notable calcareous breccia mineralization was restricted to a 10-cm-long, uraniferous, carbonaceous twig bearing a malachite halo.
21	.07	Medium-gray (N5), fine-grained, calcareous, thin-bedded sandstone. The bottom 7 cm of the unit is olive gray (5Y3/2) to medium dark gray (N4), micaceous, and noncalcareous. This assayed unit contains abundant phosphatic fish remains and visible copper mineralization.
29	.05	Olive-gray (5Y3/2), fine-grained, medium-bedded sandstone which is very micaceous on bedding surfaces.
15	.04	Badly weathered reduced shale containing oxidized zones.

of reduced lenses in the Sonestown Nose area, the occurrence is important despite the low U_3O_8 assays of a thin interval.

SONESTOWN NOSE CLUSTER C

Sonestown Nose Reduced Cap Copper-Uranium Zone

1. LOCATION:
   (a) The mineralized portion of the reduced zone that caps the Sonestown Nose (Plate 1) is located on the Peterman property and is exposed discontinuously for almost 300 m (1,000 ft) on the southwest edge of the flat on the Sonestown Nose at an elevation of about 420 m (1,380 ft). The reference point-base station is defined as the northwest end of a large mineralized outcrop at the northwest end of mineralization. The reference point is 0.62 km (0.38 mi) northeast of the confluence of Big Run and Muncy Creek, 0.58 km (0.36 mi) slightly north of east of the intersection of old U.S. Route 220 with the Sonestown-Nordmont road, and 0.15 km (0.09 mi) north of the intersection of the Klemic locality 13 reduced horizon with the Sonestown-Nordmont road, Davidson Township, Sullivan County.

	Reference point
(b) Latitude:	41°21′28″N
Longitude:	76°32′50″W

2. ASSAYS: A 35-cm (14-in.) channel sample of "maroon" and gray, medium-grained sandstone from a site 11.7 m (38.4 ft) east-southeast of the reference point has 39 ppm U_3O_8, 5,000 ppm copper, and an average radioactivity of 0.1 "mR/hr." See sample MHK 772, Appendix 3.

   A 17-cm (7-in.) channel sample of grayish-red, medium-grained sandstone containing trace malachite from a site 56.7 m (186.0 ft) east-southeast of the reference point has 24 ppm U_3O_8, 5,000 ppm copper, and an average radioactivity of 0.07 "mR/hr." A 30-cm (12-in.) channel sample of grayish-red, medium-grained sandstone containing abundant 1- to 3-mm interstitial grains of malachite from the same site has 51 ppm U_3O_8, 7,000 ppm copper, and an average radioactivity of 0.1 "mR/hr." See samples MHK 773 and 774, Appendix 3.
3. MINERALOGY:
   (a) Major: None.
   (b) Minor: Malachite as coatings on bedding partings, associated with carbonaceous plant fragments and phosphatic fish remains, and, especially at the site 56.7 m (186 ft) east-southeast of the reference point, as abundant 1- to 3-mm interstitial grains; and calcite as secondary, colorless to brown, crystalline to micro-botryoidal crusts on bedding partings or dispersed with malachite. Several calcite crusts from the site 11.7 m (38.4 ft) east-southeast of the reference point are fluorescent and phosphorescent white-tan (UV, long wave and short wave).
   (c) Trace: From the site 11.7 m (38.4 ft) east-southeast of the reference point—uranophane(?) or beta-uranophane(?) as pale-yellow, fluo-

Table 50. *Summary of Radiometric Measurements at the Sonestown Nose Reduced Cap Copper-Uranium Zone*

Located 0.75 km (0.47 mi) northeast of Sonestown.

Distance and bearing from reference point along traverse		Location	Radioactivity at location noted	Radiometric assay (eU, in ppm)	Comments
0-50 m (0-164 ft)	S57° E	0.5 m (1.6 ft)	650 cps (under ledge)	—	On a carbonaceous plant fragment bearing malachite in and around the fragment, in "maroon," medium-grained sandstone that has 0.06 "mR/hr" (average), within a 1.8-m- (6-ft-) thick reduced zone with thin calcareous breccia lenses at the base.
		5.0-8.5 m (16.4-27.9 ft)	>200 cps, or .12 "mR/hr"	50	Assay on 20-cm- (8-in.-) thick "maroon" zone within gray sandstone at 7.0 m (23 ft).
		11.0-18.0 m (36.1-59.0 ft)	≥ 200 cps, or .6 "mR/hr"	120	On the end of an enriched carbonaceous log bearing malachite in and around the log, and trace yellow secondary uranium mineral at 11.7 m (38.4 ft) (Figures 69–70). Site of channel sample and stratigraphic description (Table 51) at 11.7 m (38.4 ft).
		16.0 m (52.5 ft)		90	
		18 m (59 ft)			Malachite-bearing calcareous breccia float.
		45.5-48.0 m (149.3-157.4 ft)	≥ 200 cps, or 1.6 "mR/hr"	600	On a 4-mm- (0.16-in.-) thick, 19-cm- (7.5-in.-) long, carbonaceous plant fragment which has malachite in and around it and has a 10-cm- (4-in.-) thick "maroon" halo, located 50 cm (20 in.) above the base of the reduced zone at 47.7 m (156.5 ft), where the reduced zone is 3.4 m (11 ft) thick.
50-100 m (164-328 ft)	S68°E	54.0-68.0 m (177-223 ft)	≥ 200 cps	240	On the face, 40 cm (16 in.) below the overhang at 56.7 m (186 ft); site of channel samples and stratigraphic description (Table 52). The 56.7-m (186-ft)

					site is the richest along the 54- to 68-m (177- to 223-ft) interval, but outcrops are lacking at both ends, where mineralization is also present.
		56.7 m (186 ft)			The reduced zone is in a ≥ 3.4 m (11 ft) thickness of medium-grained sandstone which is gradational to oxidation colors at the top, and has 48 cm (19 in.) of medium-grained, "maroon" sandstone at the base. Channel samples were taken here.
		63.6 m (209 ft)			Traverse reference site on the southeast side of the support pillar at the center of the large natural overhang.
		65.3 m (214 ft)		230	On the face under a slight overhang where the reduced zone is ≥ 3.5 m (11 ft) thick, color is gradational to colors of oxidation at top, but sandstone is medium grained throughout. The radioactive zone consists of 18 cm (7 in.) of "maroon," medium-grained sandstone 35 cm (14 in.) above the base.
		83.5 m (274 ft)	400 cps		On a malachite-stained, medium- to coarse-grained sandstone float block.
		86 m (282 ft)	200 cps		On a reduced, coarse- to medium-grained sandstone which could be *in situ* or float.
100-150 m (328-492 ft)	S72°E	143-154.7 m (469-507 ft)	≥ 200 cps		Outcrops and float blocks of reduced sandstone and calcareous breccia which are slightly radioactive. Some of the reduced sandstone float blocks contain coarse carbonaceous plant fragments which are not appreciably radioactive.
		144 m (472 ft)			Large block of calcareous breccia float(?); contains trace amounts of malachite.
		149 m (489 ft)		140	On a float block containing coarse plant fossils.

Table 50. *(Continued)*

Distance and bearing from reference point along traverse		Location	Radioactivity at location noted	Radiometric assay (eU, in ppm)	Comments
150-200 m (492-656 ft)	S72°E	149-154.6 m (489-507 ft)			Radioactivity is coming through moss and humus.
		154 m (505 ft)	.06 "mR/hr"	140	On moss and humus. Float is nearly "maroon," medium-grained sandstone.
200-250 m (656-820 ft)	S72°E	211 m (692 ft)	200 cps		On a float block of "maroon," medium-grained sandstone.
		246 m (807 ft)	200 cps		On a float block of "maroon," medium-grained sandstone. Also a float block of calcareous breccia containing trace malachite.
250-300 m (820-984 ft)	S73°E	280.5 m (920 ft)	450 cps, or .06 "mR/hr"		On soil. Outcrop nearby is gray, medium-grained sandstone on top of calcareous breccia.
		294 m (964 ft)			Float block of calcareous breccia containing trace malachite.
300 m (1,000 ft) to trail	N62°E	331 m (1,086 ft)			Center of trail.

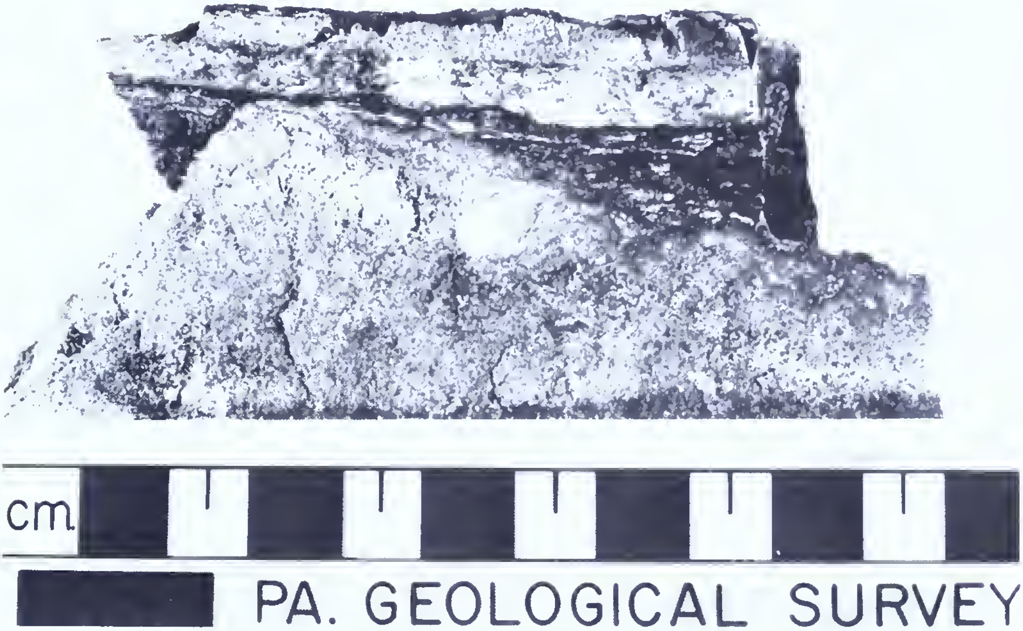

Figure 69. Carbonaceous limb and associated malachite in sandstone, from the site 11.7 m (38.4 ft) east-southeast of the reference point, Sonestown Nose Reduced Cap copper-uranium zone.

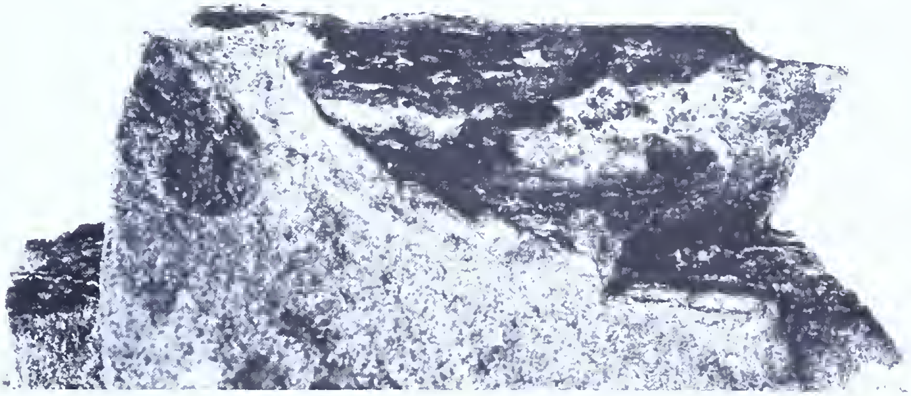

Figure 70. Reverse side of the specimen shown in Figure 69. Viewed from the end, substantial burial compression of the carbonaceous limb becomes apparent.

rescent pale-green (UV, short wave and long wave), minutely fibrous crusts associated with malachite on a carbonaceous log; brochantite as rare, emerald-green microcrystals and crusts on a carbonaceous log; chrysocolla-malachite mixture filling shrinkage cracks in vitrain; quartz as a microcrystalline partial replacement of

Table 51. *Stratigraphic Section of Catskill Formation Rocks at the Sonestown Nose Reduced Cap Copper-Uranium Zone*

Exposure is an outcrop 11.7 m (38.4 ft) S57°E of the reference point.

Thickness (cm)	Radioactivity ("mR/hr")	Lithologic description
>40	.1 .4 max.	Between medium gray (N5) and medium dark gray (N4), to grayish red (5R4/2). Medium-grained, thin-bedded, crossbedded sandstone. The 35-cm-thick assayed sample from this unit contains finely disseminated malachite and sparse carbonaceous plant fragments accompanied by malachite, 33 to 38 cm above the base. Enriched carbonaceous log with malachite and trace yellow secondary uranium mineral occurred in the bottom half of the unit (Figures 69-71).
40	.03	Between medium gray (N5) and medium dark gray (N4). Medium-grained, thin-bedded sandstone which has dark-brown oxidation specks.
25	.02	Reduced calcareous breccia which contains phosphatic fish remains and calcareous sandstone lenses.
15	.02	Medium-gray (N5), fine-grained, slightly calcareous sandstone.
>10	.03	Dark-reddish-brown (10R3/4) siltstone.

Table 52. *Stratigraphic Section of Catskill Formation Rocks East-Southeast of the Reference Point at the Sonestown Nose Reduced Cap Copper-Uranium Zone*

Exposure is an outcrop 56.7 m (186 ft) east-southeast of the reference point.

Thickness (cm)	Radioactivity ("mR/hr")	Lithologic description
>290	.025	Medium-gray (N5), medium-grained, thin-bedded, crossbedded sandstone containing 1- to 3-mm medium-dark-brown oxidation specks. The unit is gradational, becoming oxidized near the top.
17	.07	Between grayish red (5R4/2) and dusky red (5R3/4) ("maroon"). Medium-grained, thin-bedded, crossbedded sandstone. This unit contains trace disseminated malachite and makes up the upper 17-cm-thick assayed sandstone sample.
31	.1	Between grayish red (5R4/2) and dusky red (5R3/4) ("maroon"). Medium-grained, thin-bedded, crossbedded sandstone. This unit contains abundant 1- to 3-mm interstitial malachite grains, especially 15 to 25 cm above the base, and makes up the lower 30-cm-thick assayed sandstone sample.
3	~.04	Dark-greenish-gray (5G4/1) mudstone.
>6	.04	Grayish-red (5R4/2) mudstone.

a phosphatic fish remain. "Apatite" as phosphatic fish remains in calcareous breccia and sandstone; and compact, medium-gray, dolomitic material as coarse sand and small pebbles in calcareous breccia float from approximately 18.5 m (60.7 ft) east-southeast of the reference point. The dolomitic sand and pebbles are enhanced by weathering and show a thin, light-gray, dolomitic alteration rind.

4. GEOLOGIC DESCRIPTION: The occurrence consists of a discontinuous series of mineralized outcrops that extend for 294 m (964 ft) east-southeast of the reference point. The same reduced zone continues for about 300 m (1,000 ft) northwest of the reference point, where it forms a 2-m- (7-ft-) thick cap on the Sonestown Nose, but this northwest portion is barren of both copper and uranium. The mineralization observed in outcrops and float to the east-southeast of the reference point is summarized in Table 50. The zone does not appear to have been prospected.

   Although the mineralized zones in the reduced cap are thin and discontinuous, the lateral extent suggests that further studies are warranted in the Sonestown Nose area. The superposition of favorable horizons in this area is also considered promising. The flat just north of the reduced cap may also be a good area for testing geochemical and geophysical exploration methods through a relatively uniform thickness of sedimentary rock and soil.

MUNCY VALLEY CLUSTER

Jordan Borrow Pit (Noncommercial)

1. LOCATION:
   (a) The Jordan borrow pit is located 2.20 km (1.37 mi) southeast of Beech Glen and 0.40 km (0.25 mi) west of Pa. Route 42, Davidson Township, Sullivan County. The elevation is approximately 348 m (1,140 ft).
   (b) Latitude: 41°18′40″N
   Longitude: 76°34′38″W
2. ASSAYS: A 2-cm (0.8-in.) channel sample of micaceous sandstone contains 48 ppm U_3O_8 and 4,850 ppm copper, and has an average radioactivity of 0.08 "mR/hr." This micaceous sandstone contains abundant malachite and carbonaceous plant fragments and minor azurite. See sample MHK 737, Appendix 3. The stratigraphic section at the channel-sample site is described in Table 53, and the section exposed 2.5 m (8.2 ft) west of it is described in Table 54.
3. MINERALOGY:
   (a) Major: Malachite occurs as interstitial grains and muscovite-flake pigmentation in reduced sandstone; malachite also occurs in calcareous breccia and reduced sandstone as crusts on bedding partings, and associated with carbonaceous plant fragments; calcite as white to reddish-brown crusts, tiny globules, and scalenohedral microcrystals on bedding partings in oxidized, flaggy sandstone, and as secondary crusts in calcareous breccia; and opal (variety hya-

Table 53. *Stratigraphic Section of Catskill Formation Rocks at the Jordan Borrow Pit, East Site*

Exposure is at the channel-sample site, 2.20 km (1.37 mi) southeast of Beech Glen. This site is 2.5 m (8.2 ft) east of the section described in Table 54. At these low levels, the radioactivity measurements are believed to be ±0.02 "mR/hr." The section was described on September 15, 1978.

Thickness (cm)	Radioactivity ("mR/hr")	Lithologic description
11	.03	Olive-gray (5Y4/1), fine-grained, very micaceous sandstone.
1–2	.06	Dark-yellowish-brown (10YR4/2), very micaceous, fine-grained sandstone containing abundant carbonaceous plant fragments. Assayed unit.
1–2	.06	Grayish-red (5R4/2), slightly micaceous, fine-grained sandstone containing disseminated malachite.
21	.02	Dusky-brown (5YR4/2), slightly micaceous, fine-grained sandstone with brownish-black (5YR2/1) mottling. The unit was probably calcareous, especially near the base.
11	.03	Medium-light-gray calcareous breccia containing trace malachite. Phosphatic fish remains are common, but no shale chips were observed.

lite) as colorless, fluorescent bright-green (UV, short wave), very thin coatings and micro-botryoids on or under the calcite on bedding partings in flaggy sandstone.

(b) Minor: Azurite as muscovite-flake pigmentation, crusts of micro-botryoids and drusy microcrystals on bedding partings, and as vuggy druses of microcrystals associated with malachite in shrinkage cracks in carbonaceous plant fragments, all in reduced sandstone; and as surface coatings and divergent groups of lathlike microcrystals associated with carbonaceous plant fragments in calcareous breccia. "Apatite" as phosphatic fish remains (Figure 71 and color photograph 32), including complete scales of *Holoptychius* sp. and Rhizodontidae, genus and species undetermined, and partial plates of *Bothriolepis* sp., in reduced sandstone, calcareous breccia, and oxidized mudstone.

(c) Trace: Djurleite, and "chalcocite" associated with bornite, chalcopyrite, and pyrite, all as rare replacements of carbonaceous plant fragments; quartz as platy fillings in shrinkage cracks in carbonaceous plant fragments; and barite as colorless and "limonite"-stained platy crusts on carbonaceous plant fragments.

4. GEOLOGIC DESCRIPTION: The borrow pit is a largely inactive operation which only supplies "shale" on demand for relatives and friends of John Jordan. Jordan (shown in Figure 62), one of the most energetic prospectors during the uranium boom of the late 1950's and former partner of Anthony Gill, just happened to locate his pit in a lens bearing

Table 54. *Stratigraphic Section of Catskill Formation Rocks at the Jordan Borrow Pit, West Site*

Exposure is 2.5 m (8.2 ft) west of the channel-sample site on the southwest side of the pit, 2.20 km (1.37 mi) southeast of Beech Glen. The section was measured on July 25, 1978.

Thickness (cm)	Radioactivity ("mR/hr")	Lithologic description
>100	.02	Grayish-red (5R4/2), fine- to medium-grained, micaceous, flaggy sandstone. Calcite and hyalite opal (fluorescent in UV light) on bedding surfaces. Some bedding surfaces have parting-step lineations and others have ripple marks.
15	.02	Medium-light-gray (N6) to medium-gray (N5), fine- to medium-grained, micaceous sandstone.
6	.05	Mottled medium-gray (N5) to grayish-brown (5YR3/2) calcareous breccia containing phosphatic fish remains, scattered carbonaceous plant fragments (near the top), and brick-red and greenish-gray shale chips.[1]
25	.03	Grayish-red (5R4/2) siltstone having a mottled color due to centimeter-sized reduced zones which are greenish gray (5G6/1).
>160	.03	Grayish-red (10R4/2) siltstone and mudstone containing red shale clasts. Moderate amounts of burrows, rootlets, and fish-plate fragments.

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[1] Although the calcareous breccia occurs as discontinuous lenses along the pit walls, the reduced zone appears to be continuous. Float quarried earlier in 1978 shows that the calcareous breccia was then up to 27 cm thick and mottled gray, brownish gray, and greenish gray. Fish remains include complete crossopterygian scales. The top of the calcareous breccia was marked by carbonaceous plant fragments up to 28 cm long at the contact with the overlying sandstone bed. The bottom of the calcareous breccia was marked by grayish-red (10R4/2) shale clasts up to approximately 10 cm long. However, the pit walls suggest that minimal channeling has occurred at the base of the calcareous breccia zone.

copper and trace uranium. A long driveway, built in mid-1978 for a nephew who lives about halfway to Beech Glen, is composed of rock containing moderate amounts of azurite and malachite.

Sevon and others (1978, p. 77, 79) summarized the geology as follows:

> This prospect is located near the lower part of the upper third of the Catskill Formation, approximately 260 m [850 ft] below the top of the formation (total thickness about 1070 m [3,500 ft]. . . . The sequence comprises red floodplain silts and clays overlain by a scoured surface and presumed channel sands. . . . Relief on the scoured surface is small and lag deposits (calcareous breccia) on this surface appear as small, isolated pockets. Deposition of the sands was probably in a broad, shallow, perhaps poorly defined channel.

The stratigraphic section exposed in the southwestern part of the pit as of July 25, 1978 is described in Table 54. A few months prior, a thin (30-cm, or 12-in.) zone containing secondary copper bloom and extremely abundant, millimeter-sized muscovite flakes was nearly continuously exposed for 30 m (100 ft) along the west side of the pit.

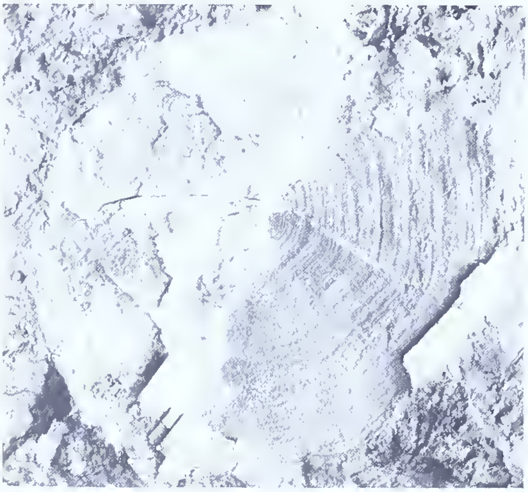

Figure 71. Phosphatic fish scale, Jordan borrow pit. The maximum diameter is 6.5 cm (approximately 2.5 in.).

Bedding in the area strikes N30°W and dips 3°NE, and subvertical joints trend N30°E. Carbonaceous plant fragments and associated malachite in reduced sandstone, trace uranium in reduced sandstone, and complete crossopterygian fish scales can be observed at the same horizon 60 m (200 ft) west of the pit, and unmineralized gray sandstone can be traced 120 m (400 ft) north from this point. In both the 60-m-west area and the pit proper, carbonaceous plant fragments up to 3 by 30 cm (1.2 by 12 in.) with radioactivities up to 0.3 "mR/hr" have been found, but typically the fragments have radioactivities of 0.1 "mR/hr."

The thin, discontinuous nature of the copper mineralization suggests that the occurrence is of no direct economic significance.

Klemic Locality 12

1. LOCATION:

(a) Klemic locality 12 consists of a number of mineralized shows in a moderate-sized reduced zone. The two channel-sample sites are designated Klemic locality 12 southwest and Klemic locality 12 northeast. Both were prospected by John Jordan.

Klemic locality 12 southwest is located on the Willis N. Myers farm in a pasture on the southeast side of the ridge, at an elevation of about 326 m (1,070 ft), 1.03 km (0.64 mi) south-southeast of Beech Glen, 1.04 km (0.65 mi) west-northwest of Hemlock Grove, and 2.51 km (1.56 mi) N86°W of the North Mountain fire tower.

Klemic locality 12 northeast is located on the Willis N. Myers farm 70 m (230 ft) N67°E of Klemic locality 12 southwest, at an elevation of about 326 m (1,070 ft), 1.03 km (0.64 mi) south-southeast of Beech Glen, 0.98 km (0.61 mi) west-northwest of Hemlock Grove, 2.46 km (1.53 mi) N85°W of the North Mountain fire tower, and 0.25 km (0.16 mi) S89°W of the W. N. Myers house, Davidson Township, Sullivan County.

	Southwest site	Northeast site
(b) Latitude:	41°19′13″N	41°19′13″N
Longitude:	76°35′04″W	76°35′02″W

2. ASSAYS: A channel sample of gray calcareous breccia, 73 ± 2 cm (29 ± 0.8 in.) thick, from the southeast side of the mini-adit at Klemic locality 12 southwest contains 10 ppm U_3O_8 and 1,150 ppm copper. See sample MHK 761, Appendix 3.

   A 51-cm (20-in.) channel sample of gray calcareous breccia from Klemic locality 12 northeast contains 6 ppm U_3O_8 and 200 ppm copper. A 19-cm (7.5-in.) channel sample of the underlying gray sandstone, which has "maroon" oxidation spots, contains 254 ppm U_3O_8, 2,200 ppm copper, 100 ppm arsenic, and 45 ppm lead. A 19-cm (7.5-in.) channel sample of the same sandstone bed, but lacking oxidation spots, contains 34 ppm U_3O_8, 550 ppm copper, 10 ppm arsenic, and 10 ppm lead. See samples MHK 769, 767, and 768, Appendix 3.
3. MINERALOGY:

   Southwest site
   - (a) Major: None.
   - (b) Minor: Calcite as clear, sub-botryoidal coatings on calcareous breccia; fluorapatite as phosphatic fish remains; and malachite in calcareous breccia and on fluorapatite.
   - (c) Trace: "Chalcocite," bornite, and composites of them as micrograins in calcareous breccia; barite as white, platy masses in calcareous breccia; azurite; and chalcopyrite(?).

   Northeast site
   - (a) Major: None.
   - (b) Minor: Malachite near carbonaceous plant fragments and sparse phosphatic fish remains.
   - (c) Trace: "Apatite" as phosphatic fish remains in calcareous breccia; barite as white, platy masses in calcareous breccia; calcite filling shrinkage cracks in carbonaceous plant fragments; and yellowish-green unknown coating.
4. GEOLOGIC DESCRIPTION: The Klemic locality 12 southwest occurrence consists of a mini-adit in an at least 3.2 m (10.5 ft) thick,[1] reduced zone of gray sandstone and calcareous breccia (Figure 72). The stratigraphy is described in detail in Table 55. The mini-adit is 90 cm (35 in.) long, 72 cm (28 in.) high, and 87 cm (34 in.) wide. If it had been continued, it would have trended northeast. Bedding is subhorizontal, forming a large flat, and the mini-adit is near the west end of the ledge below the flat.

   Phosphatic fish remains are very common in the calcareous breccia at the mini-adit. Identified vertebrate fossils from this locality include partial plates of a placoderm identified as *Bothriolepis* sp., and crossopterygians identified as *Holoptychius* sp. (Figure 73), some as complete

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[1] Based on mapping of float, the reduced zone is 10.2 m (33.5 ft) thick and the overlying oxidized siltstone is only 30 cm (12 in.) thick. Above this, there appears to be an additional 5 m (16 ft) or more of reduced sandstone.

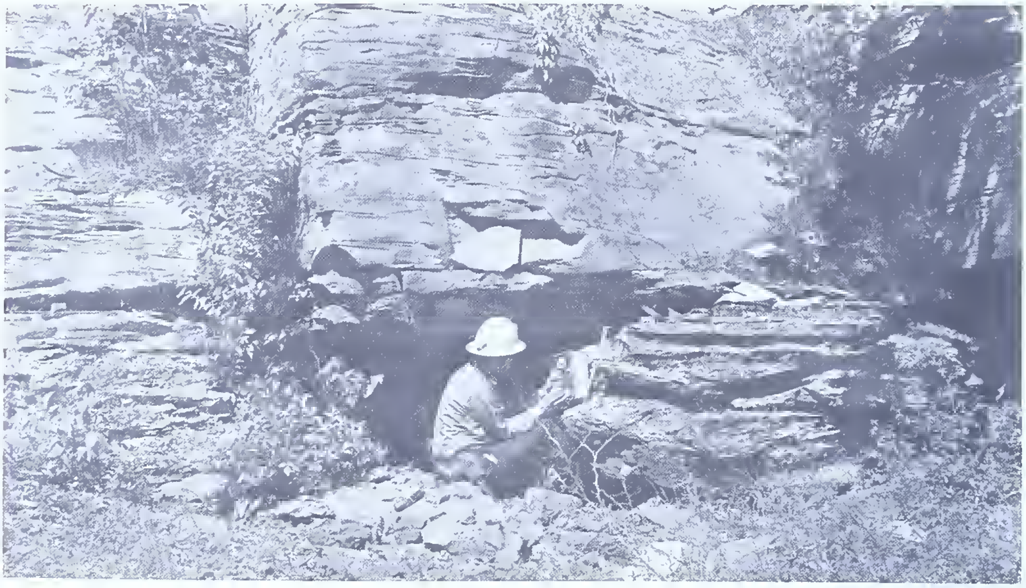

Figure 72. Mini-adit excavated by J. V. Jordan at Klemic locality 12, southwest occurrence. The scintillometer is at the site of channel sample MHK 761 in calcareous breccia. The rock above the level of the geologist's head is gray sandstone. The 81-cm- (32-in.-) thick calcareous breccia unit is rich in phosphatic fish remains.

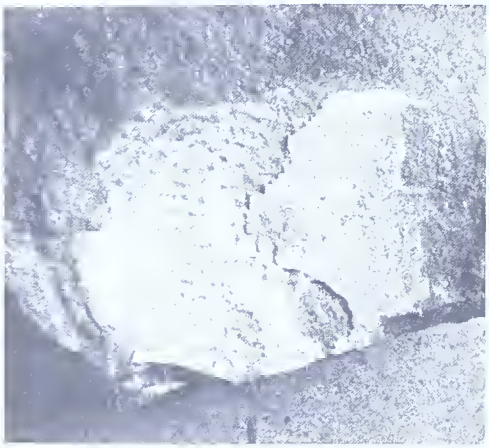

Figure 73. *Holoptychius* sp., phosphatic fish scale, 32 mm (1.26 in.) in diameter, from McCauley prospect 18 (Avery Brothers uranium adit); similar to abundant specimens from Klemic locality 12, southwest occurrence. William Penn Memorial Museum specimen V107.

scales, and remains from the family Rhizodontidae (Figure 74), genus and species undetermined, some as complete scales. The age of this identified suite is Late Famenian (late Late Devonian) (Crocker, 1980). Crocker described the paleoenvironment of the mini-adit locality and the Jordan borrow pit[1] (p. 29) as follows: "All of the evidence, then, seems to argue for fresh water fluviatile conditions, with some combination of

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[1] The vertebrate fossil identifications for the Jordan borrow pit are identical to those of the mini-adit at Klemic locality 12 southwest.

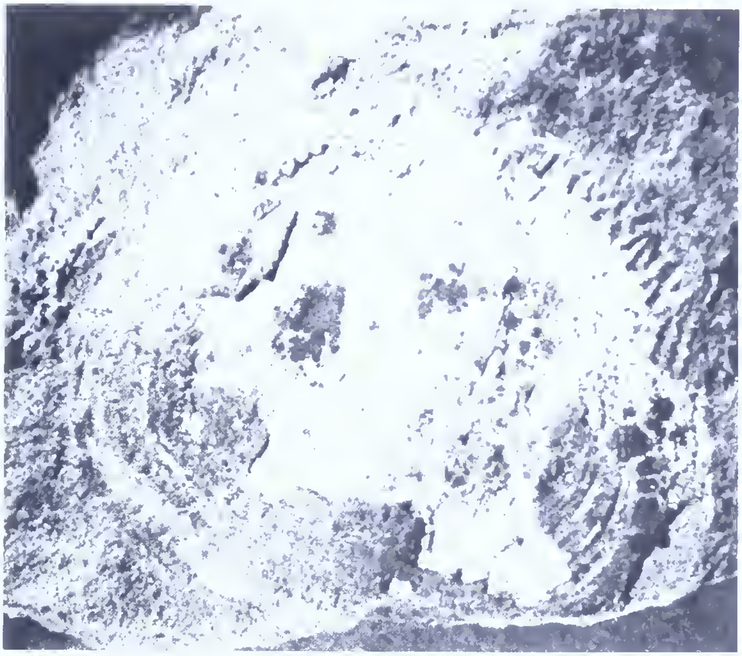

Figure 74. Phosphatic fish scale from the Rhizodontidae family, genus and species undetermined, 51 mm (2.0 in.) in diameter, from Jordan borrow pit. Similar to abundant specimens from Klemic locality 12, southwest occurrence. William Penn Memorial Museum specimen V106; collected by J. H. Way.

slow, stagnant, poorly oxygenated waters, and occasional droughts due to the conditions imposed by mountain building to the east.'' Some of the remains are coated with malachite and one specimen may have contained chalcopyrite in the fossae.

Table 55. *Stratigraphic Section of Catskill Formation Rocks at Klemic Locality 12, Southwest Site*

Exposure is above and on the southeast corner of the southwest mini-adit.

Thickness (cm)	Radioactivity (''mR/hr'')	Lithologic description
>240	.02	Medium-light-gray (N6), fine-grained, medium-bedded sandstone which is micaceous on bedding surfaces and contains 1- to 3-mm medium- to dark-brown-weathering specks. This unit is thin bedded and contains lenses of calcareous breccia up to 10 cm thick near the bottom.
81	.05	Gray calcareous breccia containing abundant grayish-red (5R4/2) shale and siltstone chips near the bottom. Malachite is fairly abundant, and phosphatic fish remains, often as large crossopterygian scales, occur abundantly in the bottom half of this assayed unit.
>20	.03	Grayish-red (5R4/2), highly micaceous siltstone.

Radioactivity at the southwest occurrence is erratic. The gray sandstone, which is ≥ 2.4 m (8 ft) thick, yields only 0.02 "mR/hr," and the underlying calcareous breccia yields 0.05 "mR/hr" on the average. The stratigraphic position of zones of greater-than-average radioactivity in the calcareous breccia varies considerably over short distances along strike. In some places, the top of the calcareous breccia is anomalous with respect to radioactivity, whereas 1 m (3 ft) along strike only the bottom or middle may be relatively enriched. The highest reading observed in this area, 0.4 "mR/hr," was obtained on fossil plant fragments in a 1-cm- (0.4-in.-) thick lamina above the calcareous breccia about 3 m (10 ft) east of the mini-adit.

The area between Klemic locality 12 southwest and a point 60 m (200 ft) S79°W contains slightly radioactive gray sandstone. Radioactivities up to 350 cps on contact were observed.

Klemic locality 12 northeast, 70 m (230 ft) N67°E of Klemic locality 12 southwest, consists of uranium and copper mineralization in ledge underhangs and a very small open cut. At the channel-sample site, located 5.0 m (16.4 ft) northeast of the open cut, uranium mineralization is restricted to a 19-cm- (7.5-in.-) thick, gray sandstone bed. Where this bed contains centimeter-sized oxidized blotches, it is moderately rich (254 ppm U_3O_8), whereas the same rock without blotches is moderately lean (34 ppm U_3O_8). Except for trace malachite in the overlying calcareous breccia, both the overlying and underlying calcareous breccias are barren. The stratigraphy at the Klemic locality 12 northeast site is described in Table 56. Sparse but moderate-sized plant fragments in this area yield up to 0.6 "mR/hr," and one small limb in the 19-cm (7.5-in.) sandstone

Table 56. *Stratigraphic Section of Catskill Formation Rocks at Klemic Locality 12, Northeast Site*

Exposure is 5.0 m (16.4 ft) northeast of the center of a very small open cut at the northeast site.

Thickness (cm)	Radioactivity ("mR/hr")	Lithologic description
>100	.025	Medium-light-gray (N6), fine-grained, medium-bedded, micaceous sandstone.
51	.035	Medium-gray (N5) calcareous breccia. This assayed unit contains trace malachite and sparse phosphatic fish remains.
19	.20	Medium-light-gray (N6) to medium-gray (N5), fine-grained, micaceous sandstone which contains blotches that are between grayish red (5R4/2) and dusky red (5R3/4) ("maroon"), carbonaceous plant fragments, and malachite. This assayed unit is totally gray immediately along strike.
20	.06[a]	Medium-gray (N5) calcareous breccia.
>10	.05[a]	Between grayish red (5R4/2) and blackish red (5R2/2). Siltstone.

[a] Probably high because of geometry.

bed containing "maroon" blotches yielded a maximum of 0.8 "mR/hr."

From Klemic locality 12 northeast, one can observe erratic mineralization at approximately the same horizon for about 250 m (820 ft) to the north-northeast. The northeasternmost limit of mineralization is marked on Plate 1 with a quarry symbol. One large piece of float in this interval yielded up to 0.8 "mR/hr" or 400 ppm eU on a trace of yellow secondary uranium ochre. Ten centimeters (4 in.) of calcareous breccia, located N42°W of W. N. Myers' barn at the base of a reduced zone (at the northernmost quarry symbol on Plate 1), yields 150 ppm eU for a strike length of nearly a meter (3 ft), but this discontinuous zone is typically only a few centimeters thick over its total length of about 30 m (100 ft).

Klemic locality 12 is of interest because of the length and thickness of reduced sandstone and calcareous breccia. The erratic distribution of mineralization, however, should discourage more than academic research in this lower portion of the Catskill Formation. Equally discouraging is the large area of apparently barren gray sandstone capping the same ridge about 0.5 km (0.31 mi) to the southwest.

McCauley Prospect 26

1. LOCATION:
   (a) The prospect is located on the S. Ledger property on the south, wooded edge of a flat meadow, at an elevation of 353 m (1,160 ft), 2.0 km (1.2 mi) north of Strawbridge. The prospect is approximately 240 m (790 ft) S22°E of the large barn on the southwest side of the curve in the secondary road from Kedron Church to Pa. Route 42 and 2.43 km (1.51 mi) west of Beech Glen, Shrewsbury Township, Sullivan County. The prospect is 0.89 km (0.55 mi) northeast of the boundary with Lycoming County.
   (b) Latitude: 41°19′50″N
   Longitude: 76°37′01″W
2. ASSAYS: A 20-cm (8-in.) channel sample of gray calcareous breccia contains 25 ppm U_3O_8 and 5,400 ppm copper, and the overlying 64 cm (25 in.) of mostly gray sandstone contains 6 ppm U_3O_8 and 1,100 ppm copper. See samples MHK 763 and 762, Appendix 3. Because the mineralization is notably discontinuous, radiometric readings were taken at 5-m (16.4-ft) intervals along the face, beginning at the southeast end. These data and location adjustments necessitated by overburden are given in Table 57.
3. MINERALOGY:
   (a) Major: None.
   (b) Minor: In calcareous breccia—malachite as coatings and microbotryoids; "chalcocite" associated with minor bornite as micrograins; and "chalcocite" as rare partial replacements of phosphatic fish remains. The "chalcocite" is moderately rich in the lower half. Malachite is rare in reduced sandstone near the base.

Table 57. *Radiometric Measurements along McCauley Prospect 26*

Measurements were taken along the 41-m- (134-ft-) long, N45 °W-trending exposure at McCauley prospect 26, 2.43 km (1.51 mi) west of Beech Glen.

Distance northwest from southeast end of prospect (m)	(ft)	eU (ppm)		Radioactivity ("mR/hr")
0	0	20		.05
5	16.4		Covered	
10[a]	32.8	60		.06
15	49.2		Covered	
19	62.3	40		.05
20.5	67.2	40		.05
25	82.0	20		.05
30	98.4	20		.03
34	111.5	30		.03
38.5	126.3	20		.05

[a] The channel samples and stratigraphic descriptions were taken at 10.5 m (34.4 ft).

(c) Trace: In calcareous breccia—fluorapatite(?) as phosphatic fish remains; chrysocolla(?) as micro-botryoids; rare azurite; and brochantite(?).

4. GEOLOGIC DESCRIPTION: The prospect consists of a 41-m- (135-ft-) long, partly excavated ledge face that trends approximately N45 °W

Table 58. *Stratigraphic Section of Catskill Formation Rocks at McCauley Prospect 26*

Exposure is 10.5 m (34.4 ft) northwest of the southeast end of the open cut.

Thickness (cm)	Radioactivity ("mR/hr")	Lithologic description
>22	.04	Between grayish red (5R4/2) and brownish gray (5YR4/1). Fine-grained, thin-bedded, crossbedded sandstone. Very micaceous on bedding surfaces. This unit is included in the upper section of the 64-cm-thick assayed sandstone sample.
~40	.05	Medium-gray (N5), fine-grained, thin-bedded, crossbedded sandstone which is micaceous on bedding surfaces. This assayed unit is transitional to between grayish red (5R4/2) and brownish gray (5YR4/1) near the upper contact, and contains trace malachite near the bottom.
20	.07	Between medium gray (N5) and medium dark gray (N4). Calcareous breccia containing malachite and sparse phosphatic fish remains; assayed unit.
>24	.03	Grayish-red (10R4/2) calcareous siltstone with medium-gray (N5) mottling.

for most of its length and approximately N65 °W near the southeast end. The mineralized calcareous breccia is about 2 m (7 ft) below the level of the meadow flat. There may have been an undercut or short adit from 14 to 19 m (46 to 62 ft) from the southeast end, but this area has now caved in. The maximum radioactivity, 0.25 "mR/hr," was observed under an overhang located 13.1 m (43 ft) from the southeast end. The essentially vertical joints trend N28 °E. The stratigraphy is described in Table 58. Despite the substantial, maximum thickness of the reduced zone of 1.4 m (4.6 ft) and its lateral extent, the discontinuous nature of the mineralization and low assay values suggest that the occurrence is not of direct economic significance.

McCauley prospect 27 may have been located in the scraped area just south of the large barn (Plate 1 of Mahar, 1978). The bedrock in this area is gray sandstone, but it is not anomalously radioactive. McCauley prospect 25, as located by Mahar, is on the J. Houseknecht property. Neither reduced nor radioactive rock was found, and the owner reported that the only excavation resulted from demolition of a barn several years ago.

Shultz Copper Adit

1. LOCATION:
   (a) The adit is located on the Robert Shultz tract on the south side of a hill approximately 62 m (205 ft) above the level of U.S. Route 220, about halfway between Muncy Valley and Sonestown, Davidson Township, Sullivan County. The adit is north of a sharp bend from north to west in Muncy Creek, N59½ °W of the spire of the new Methodist church, and 1.61 km (1.0 mi) east of Muncy Valley. This is north-northeast of bench mark 918, but the adit is best approached by way of the first hollow to the east.
   (b) Latitude: 41°20′44″N
   Longitude: 76°34′02″W
2. ASSAYS: A 47-cm (18.5-in.) channel sample of gray shale and siltstone contains 10 ppm U_3O_8, 1,000 ppm copper, and approximately 1,000 ppm barium. A 26-cm (10-in.) channel sample of the underlying gray sandstone, which is "maroon" near the lowest point sampled, contains 110 ppm U_3O_8 and 3,800 ppm copper. Field radiometric assay yielded 30 ppm eU in the upper unit and 100 ppm eU in the lower unit. See samples PRS–6 and 7, Appendix 3.
3. MINERALOGY:
   (a) Major: None.
   (b) Minor: None.
   (c) Trace: Malachite as thin coatings on bedding partings in gray siltstone and near sparse, carbonaceous plant fragments; and trace light-green chrysocolla associated with the malachite and "limonite."
4. GEOLOGIC DESCRIPTION: The prospect consists of a 32.5-m- (107-ft-) long main adit and dump and a vague, possible small prospect 18 m

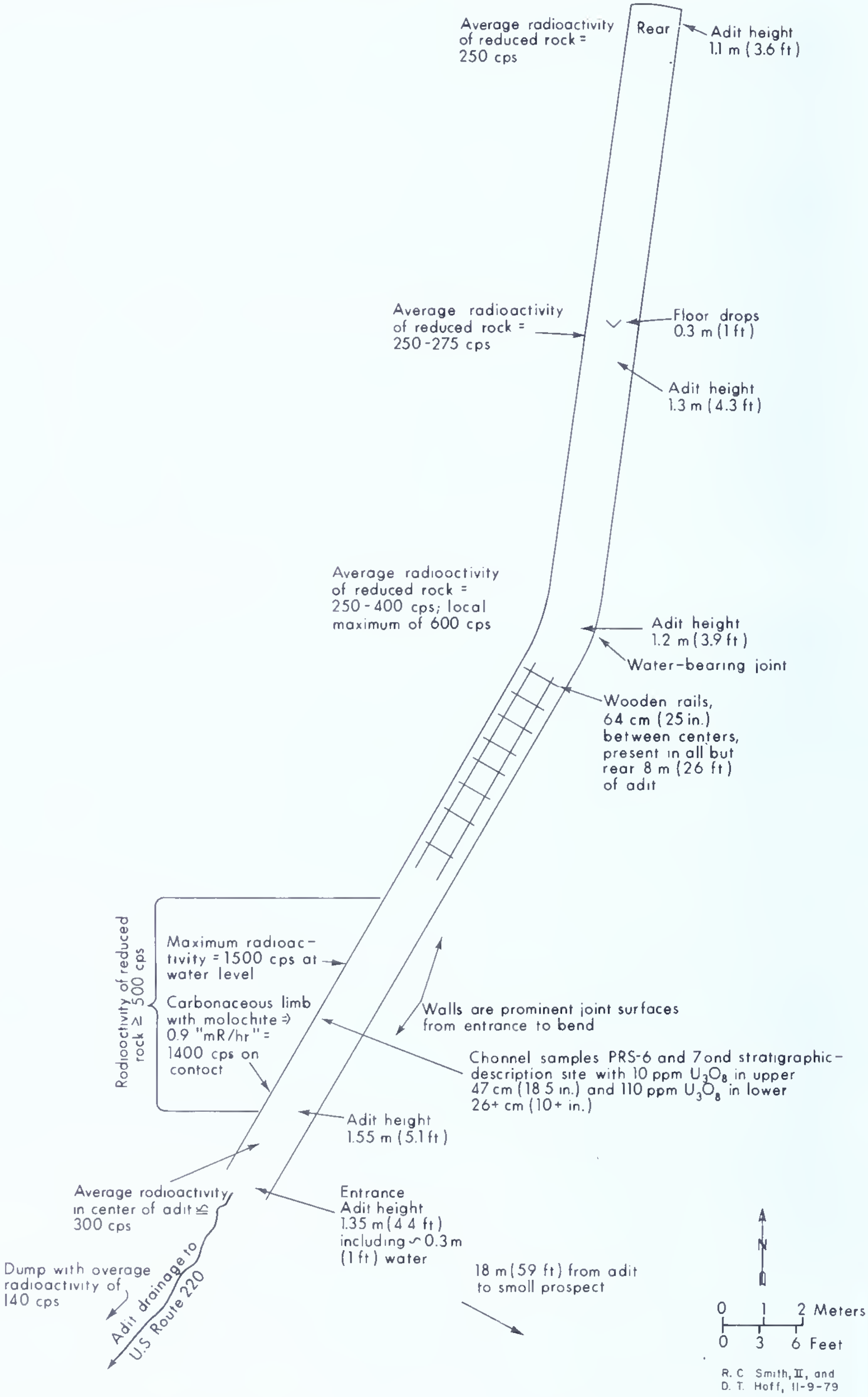
Rear
Adit height 1.1 m (3.6 ft)
Average radioactivity of reduced rock = 250 cps
Average radioactivity of reduced rock = 250-275 cps
Floor drops 0.3 m (1 ft)
Adit height 1.3 m (4.3 ft)
Average radioactivity of reduced rock = 250-400 cps; local maximum of 600 cps
Adit height 1.2 m (3.9 ft)
Water-bearing joint
Wooden rails, 64 cm (25 in.) between centers, present in all but rear 8 m (26 ft) of adit
Radioactivity of reduced rock ≥ 500 cps
Maximum radioactivity = 1500 cps at water level
Carbonaceous limb with malachite ⇒ 0.9 "mR/hr" = 1400 cps on contact
Walls are prominent joint surfaces from entrance to bend
Channel samples PRS-6 and 7 and stratigraphic-description site with 10 ppm U_3O_8 in upper 47 cm (18.5 in.) and 110 ppm U_3O_8 in lower 26+ cm (10+ in.)
Adit height 1.55 m (5.1 ft)
Average radioactivity in center of adit ≦ 300 cps
Entrance Adit height 1.35 m (4.4 ft) including ~0.3 m (1 ft) water
Dump with average radioactivity of 140 cps
Adit drainage to U.S. Route 220
18 m (59 ft) from adit to small prospect
N
0 1 2 Meters
0 3 6 Feet
R. C. Smith, II, and D. T. Hoff, 11-9-79

Figure 75. Plan map of Shultz copper adit, 1.6 km (0.99 mi) east of Muncy Valley, Lycoming County.

(59 ft) to the southeast. As shown in Figure 75, the adit follows a pronounced set of joints from the entrance to the bend at 16.5 m (54.1 ft). Because the adit height is typically only 1.3 m (4.3 ft), including about 0.3 m (1 ft) of water on the floor, it is difficult to work in the adit up to the bend. Beyond the bend, the abundance of bats hanging from the ceiling more than offsets the shallower water. When the water level in the adit was temporarily reduced, a set of wooden rails having 64 cm (25 in.) between centers was observed on the floor of the outer two thirds of the adit.

In general, the reduced rock at and below the water line in the outer half of the adit is moderately mineralized with uranium and trace copper. The observed dump, on the other hand, yields an average radioactivity of only 140 cps and contains only traces of malachite. This apparent contrast may be due to the fact that the first-mined, mineralized rock from near the entrance has been thoroughly covered over in the dump with the barren, oxidized rock removed last from the rear of the adit.

Table 59. *Stratigraphic Section of Catskill Formation Rocks at the Shultz copper adit*

Exposure (A) is above the roof of the adit at the entrance; exposure (B) is on the west face of the adit 4.6 m (15 ft) from the entrance.

Thickness (cm)	Radioactivity ("mR/hr")	Lithologic description
(A) >300	.03	Grayish-red (5R4/2), fine-grained, micaceous, thin-bedded sandstone. The unit contains sparse medium-gray (N5) laminae and several shale-siltstone zones near the bottom, and cavities up to 3 cm where calcite has weathered in the middle portion.
(B) ≥ 45	.04	Grayish-red (5R4/2), thin-bedded siltstone. The unit appears to be medium bedded, in part, along joint surfaces.
10	.04	Grayish-red (5R4/2) to blackish-red (5R2/2) shale containing minor medium-gray (N5) laminae.
47	.07	Between medium gray (N5) and medium dark gray (N4). Laminated to thin-bedded, interbedded shale and siltstone containing trace malachite. The upper, 47-cm-thick assayed sample was taken in this unit.
≥ 26	.15 .20 max.	Between medium gray (N5) and medium dark gray (N4), except near the bottom, where unit is between grayish red (5R4/2) and dusky red (5R3/4) ("maroon"). Laminated to thin-bedded siltstone and fine- to medium-grained sandstone. This unit appears to be medium bedded along joint surfaces. The unit is predominantly siltstone in the upper half and sandstone in the lower half, contains sparse carbonaceous plant fragments and malachite, and is included in the lower, 26-cm-thick assayed sample.

The stratigraphy exposed in the northwest adit wall at the carbonaceous limb 2.3 m (7.5 ft) from the entrance can be summarized from roof to floor as follows: $\geq$ 30 cm (12 in.) of grayish-red siltstone; 10 cm (4 in.) of gray, medium-grained sandstone; 33 cm (13 in.) of grayish-red shale and siltstone; 35 cm (14 in.) of gray, interbedded shale and siltstone containing minor grayish-red laminae; and $\geq$ 44 cm (17 in.) of gray, fine- to medium-grained sandstone containing minor grayish-red laminae. The planar bedding surfaces and uniformity of the reduced beds (Table 59) suggest deposition under placid conditions typical of many of the copper-uranium occurrences near the base of the Catskill Formation in the project area.

FRONT CLUSTER

Sheets "Coal Mine" Uranium-Lead Occurrence

1. LOCATION:
   (a) The well-concealed entrance to the adit is located on the Richard and Frank Sheets property near the top of a N70°W-trending ledge overlooking Trout Run, 1.48 km (0.92 mi) north of Muncy Valley, Davidson Township, Sullivan County. This is about 2.1 km (1.30 mi) due west of the large cemetery in Sonestown. The adit entrance is about 30 m (100 ft) N38°W of an unusually large oak tree and 3 m (10 ft) lower in elevation than the pond (the edge of which is about 50 m (165 ft) N10°E of the entrance). The elevation is estimated to be approximately 414 m (1,360 ft). This occurrence is 170 m (560 ft) S60°E of the Upper Catskill Reduced Zone copper occurrence.
   (b) Latitude: 41°21′28″N
   Longitude: 76°35′03″W
2. ASSAYS: An 85-cm (34-in.) channel sample of gray shale and siltstone containing pyrite and coal seams[1] up to 2 cm (0.8 in.) thick has 11 ppm U_3O_8, 45 ppm copper, and 1,600 ppm lead. The underlying 34 cm (13 in.) of gray, pyritic sandstone containing minor "maroon" blotches has 67 ppm U_3O_8 and 140 ppm copper. See samples PRS-4 and 3 (Appendix 3) and Table 60.
3. MINERALOGY:
   (a) Major: Pyrite as coarse nodules with cubic crystal faces in shale,[2] as selective replacements up to 1 cm (0.4 in.) thick in coaly layers, at times preserving fine details of replaced wood, and as tiny, elongated grains disseminated in vitrain.

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[1] A picked sample of coal, analyzed by the U.S. Geological Survey, contains 47.7 percent ash with an oxide content, in percent on an ash basis, as follows: SiO_2, 22.0; Al_2O_3, 2.53; CaO, 0.35; MgO, 0.17; Na_2O, 0.15; K_2O, 0.69; "Fe_2O_3," 57.0; TiO_2, 0.18; P_2O_5, 0.02; and SO_3, 5.2. The trace-element content, in parts per million on a whole-coal basis, is as follows: Ag, 11; As, 489; B, 33; Ba, 124; Be, 0.7; Br, 2.8; Cd, 0.17; Ce, 7.5; Cl, 100; Co, 18; Cr, 9.3; Cs, 0.4; Cu, 130; Eu, 0.19; F, 20; Ga, 7.2; Hf, 0.5; Hg, 0.29; La, 4; Li, 5.2; Lu, 0.1; Mn, 21; Mo, 57; Nb, 4; Ni, 14; Pb, 620; Re, 4.8; Sb, 1.8; Sc, 1.7; Sm, 0.6; Sr, 24; Ta, 0.09; Tb, 0.3; Th, 1; Tl, 52; U, 2.5; V, 14; Y, 5.7; Yb, 0.6; Zn, 27; Zr, 31. Note the low U content.

[2] One collected 2- by 5-cm (0.8-by 2-in.) nodule shows postdepositional bending of surrounding shale-siltstone-coal beds which occurred during the nodule's growth stages.

(b) Minor: Galena associated with quartz as thin cleat fillings in coal seams[1]; melanterite(?) as white efflorescent coatings on pyrite.

(c) Trace: Chalcopyrite as rare grains associated with malachite; anglesite as thin gray coatings on galena.

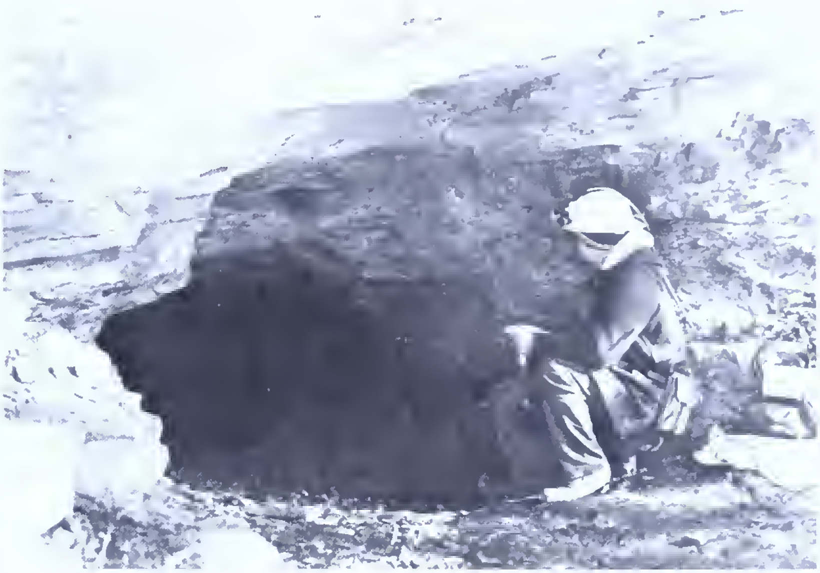

Figure 76. Entrance to Sheets "coal mine," near the top of a narrow ledge overlooking Trout Run. Photograph by D. T. Hoff, November 16, 1979.

4. GEOLOGIC DESCRIPTION: The "coal mine" consists of a 12.4-m-(41-ft-) long adit that trends N25°E and plunges 10°NE. At the entrance (Figures 76 and 77), the adit is 1.5 m (5 ft) high and 1.7 m (6 ft) wide. At a point 8.5 m (28 ft) from the entrance, the adit is 1.1 m (3.6 ft) high and 1.7 m (6 ft) wide. Beginning 8.5 m (28 ft) from the entrance, there is progressively deeper water on the adit floor. Beyond the measured 12.4 m (41 ft) of adit length there is an additional underwater undercut to the north and northeast. The water depth at the undercut was estimated to be $\leq$ 1 m (3 ft), but this area was not entered because of blizzard conditions and distance to the jeep. There is a lower, 1.5-m- (5-ft-) high adit 16 m (52 ft) below the main adit (measured from the roof of the lower adit to the floor of the main adit).

The "coal mine" is located near the top of a very extensive reduced zone. Approximately 4 m (13 ft) above the roof of the adit, the colors become transitional to grayish red, whereas there is 25 m (82 ft) of reduced rock below the roof of the adit. Directly below the "coal mine" the base of the reduced zone contains coarse- and medium-grained sandstones such as those exposed in the roof of the lower adit, which is 8 m (26 ft) above the base of the reduced zone, and those between the roof of the lower adit and the floor of the main "coal mine." Several tens of meters to the southeast of the lower adit, there are excellent exposures of the base of the same reduced zone. Some of these contain trace malachite and phosphatic fish fragments in basal calcareous breccias that have detrital quartz grains up to 2 mm. Somewhat more substantial mineralization in basal calcareous breccia of the same reduced zone to the northwest is described under the section on the Upper Catskill Reduced Zone copper occurrence.

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[1] Based on synchronized cleavage reflections, all galena within a given coal fragment has a constant orientation.

Coal seams over 2 cm (0.8 in.) thick and 1.1 m (3.6 ft) long are common in the main adit. These coal seams have a blocky parting, consist mostly of vitrain (semi-anthracite rank estimated by eye) with minor fusain laminae. Some of the latter are replaced to varying degrees by pyrite, and in some samples the texture of individual wood fibers is preserved. Thin layers of galena have filled in the cleat cracks and appear to postdate the pyrite. As determined by exposed, weathered coal and radioactivities of 200 cps or more, this mineralized zone can be traced 6.5 m (21 ft) N70°W and 9.7 m (32 ft) S70°E from the center of the adit. The mineralized lens thins appreciably toward these northwest and southeast ends, but an area of at least 16 by 2 m (52 by 7 ft) is observable. One local "hot spot" yielding about 500 cps occurs 4.5 m (15 ft) southeast of the adit center.

The stratigraphy at the channel-sample site, on the east-southeast face and floor 5.9 m (19.4 ft) from the entrance, is described in Table 60. The

Table 60. *Stratigraphic Section of Catskill Formation Rocks at the Sheets "Coal Mine" Uranium-Lead Occurrence*

Exposure (A) is above the roof of the adit at the entrance; exposure (B) is on the east-southeast face and floor, 5.9 m (19.4 ft) from the entrance to the adit.

Thickness (cm)	Radioactivity ("mR/hr")	Lithologic description
(A) >100	.03	Grayish-red (5R4/2), fine-grained, thin-bedded, crossbedded sandstone.
~400	.03	Medium-gray (N5), medium-grained, fining-upward, thin- to medium-bedded, crossbedded sandstone. The color of the unit is transitional at the top to between medium gray (N5) and grayish red (5R4/2); laminae near the top are moderate brown (5YR3/4). Cavities up to 20 cm in diameter occur near the base of unit where concentrations of disseminated pyrite(?) have weathered (Figure 78).
(B) 85	.06 .10 max. (near top)	Between medium gray (N5) and medium dark gray (N4). Interbedded pyritic shale and siltstone, which exhibit crossbedding and disturbed bedding. This upper assayed unit contains pyrite nodules up to 2 by 5 cm, and abundant, but discontinuous, coal seams up to 2 cm thick and 1.1 m long, containing pyrite and galena.
>35	.10 .14 max.	Medium-dark-gray (N4), medium-grained, thin-bedded sandstone which is medium light gray (N6) near the top and contains scattered "maroon" color zonation. This lower assayed unit is pyritic and contains trace chalcopyrite and malachite.

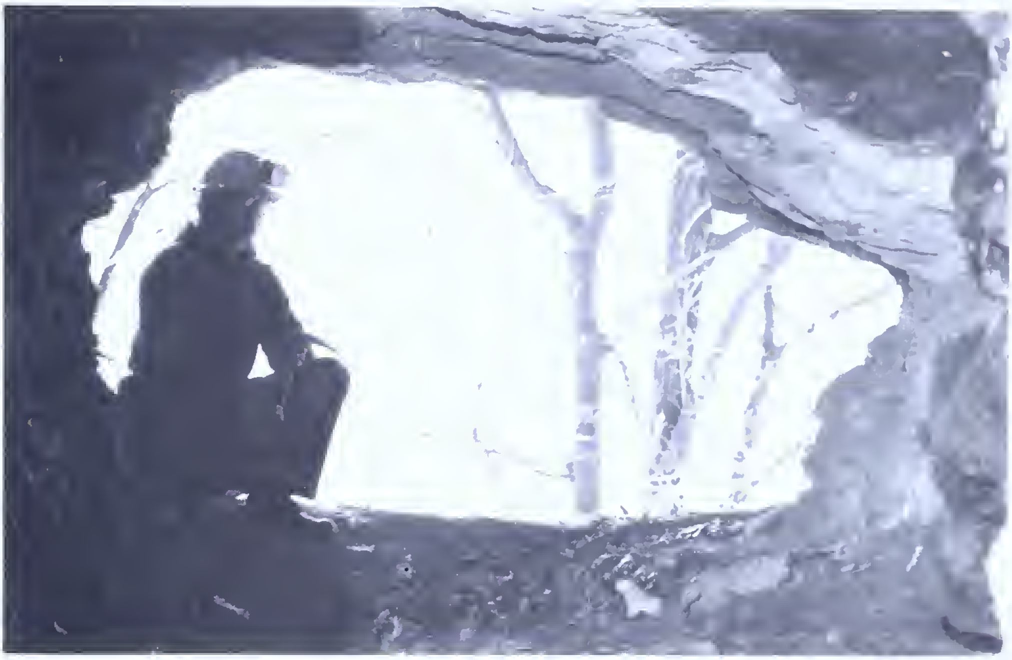

Figure 77. View looking out of Sheets "coal mine," showing the present irregular cross section of the adit, which is in reduced sandstone.

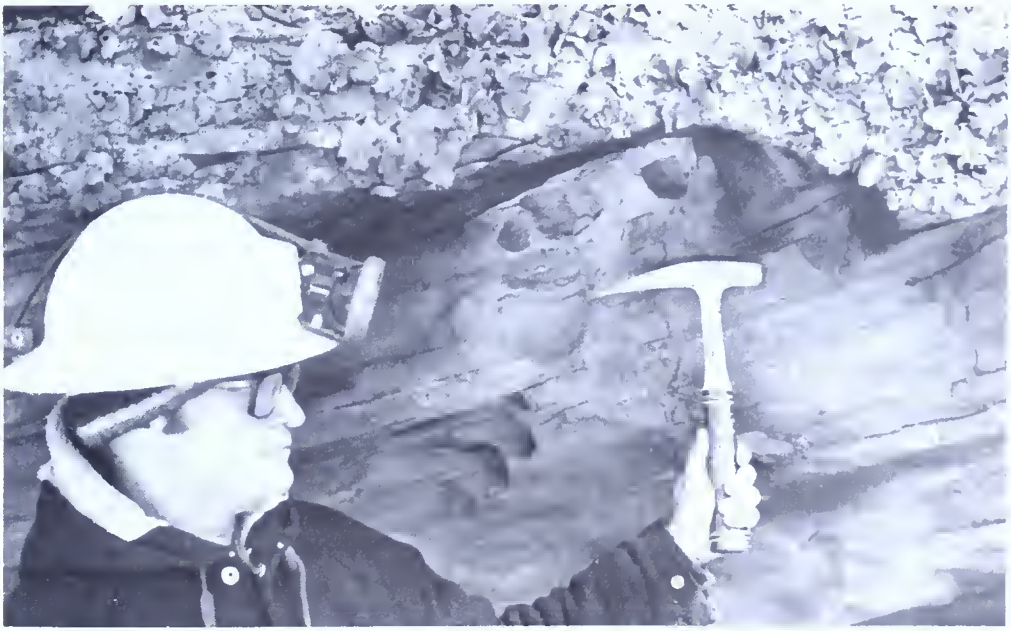

Figure 78. Cavities in medium-grained, reduced sandstone that may be related to the weathering of disseminated pyrite, above the roof of Sheets "coal mine." Lichen growth on the cavity-bearing unit appears to be limited.

upper, 85-cm (33-in.) sampled unit yielded a radioactivity from about 500 cps at the top to 700 cps at the base and a radiometric assay of 40 ppm eU. The lower, 34-cm (13-in.) sampled unit yielded a radioactivity of about 950 cps and a radiometric assay of 200 ppm eU. Considering the extreme abundance of pyrite, complete lack of calcareous units (0.05 to 0.1 percent calcium), low vanadium (70 to 100 ppm), absence of phosphatic remains, presently fixed nature of the carbon, and topographic location, it seems likely that much of the uranium may have been lost via acid leaching. The assumed depositional environment, a backswamp in otherwise porous sands, seems to have had a great potential for fixing uraniferous groundwater solutions. Thorough exploration of the reduced sandstones along and capping this ridge is strongly recommended. Radon soil gas studies may prove fruitful.

Based on its occurrence in thin, undeformed sheets along cleat parting in the vitrain, it seems reasonable to assume that the galena and quartz were introduced either near the end of or after the Alleghanian orogeny. This is based on Nickelsen and Hough's (1967) study showing that joints and presumably cleats were not developed until the Alleghanian orogeny and that severe deformation would have disoriented the crystallographic orientation of galena occurring in coal beds within an otherwise competent sandstone unit. The strong correlation of lead with uranium in the sandstone host deposits indicates that the uranium may have been introduced with the lead. Only a few examples are available (such as from the Fort Sumpter uranium prospect), but textures suggest that most galena is younger than associated copper sulfides.

The original purpose and age of excavation of the "coal mine" are unknown. It contains only negligible copper. It certainly predates the uranium boom of the late 1950's, based on discussions with the former owner (Jane Sheets, personal communication, November 1979), condition of the mine and especially the dump, and the rich, unexcavated uranium (in the adit floor). Perhaps what was initiated by a local prospector in search of coal was continued under the lure of the thin, silver-colored galena streaks.

Upper Catskill Reduced Zone Copper Occurrence

1. LOCATION:
   (a) The occurrence, which is probably on the Richard and Frank Sheets property, is located near the top of the northwest-trending bluff overlooking Trout Run, 1.57 km (0.98 mi) north of Muncy Valley, Davidson Township, Sullivan County. This is about 2.28 km (1.42 mi) due west of the large cemetery in Sonestown and near the boundary with Shrewsbury Township. The reference point, the northwest corner of a large monolith fallen from an overhang, is 170 m (558 ft) N60°W of the Sheets "coal mine" and slightly lower in elevation. The reference point and mineralization can best be found by tracing the reduced zone to near the northwest end of its outcrop exposure.

(b) Latitude: 41°21′31″N
Longitude: 76°35′09″W

2. ASSAYS: A 22-cm (8-in.) channel sample of gray calcareous breccia contains 8 ppm U_3O_8 and 2,000 ppm copper. A radiometric field assay yielded 20 ppm eU. See sample PRS–5, Appendix 3.
3. MINERALOGY:
   - (a) Major: Calcite, some of which fluoresces dull red (UV, short wave), as a clear, colorless matrix (surrounding the coarse detrital sand) having optical continuity over areas of about 1 cm (0.4 in.) in calcareous breccia.
   - (b) Minor: None.
   - (c) Trace: In calcareous breccia—malachite and rare azurite associated with sparse, disseminated "chalcocite" and minor bornite; crust of secondary calcite which fluoresces tan- to greenish-white (UV, long wave and short wave), containing a white unidentified substance that is insoluble in dilute hydrochloric acid and fluoresces green (UV, short wave) and blue-white (UV, long wave); and "apatite" as phosphatic fish remains.
4. GEOLOGIC DESCRIPTION: This occurrence is located in natural outcrops at the extreme base of a large, complex reduced zone. Although located in the same reduced zone as the Sheets "coal mine," this occur-

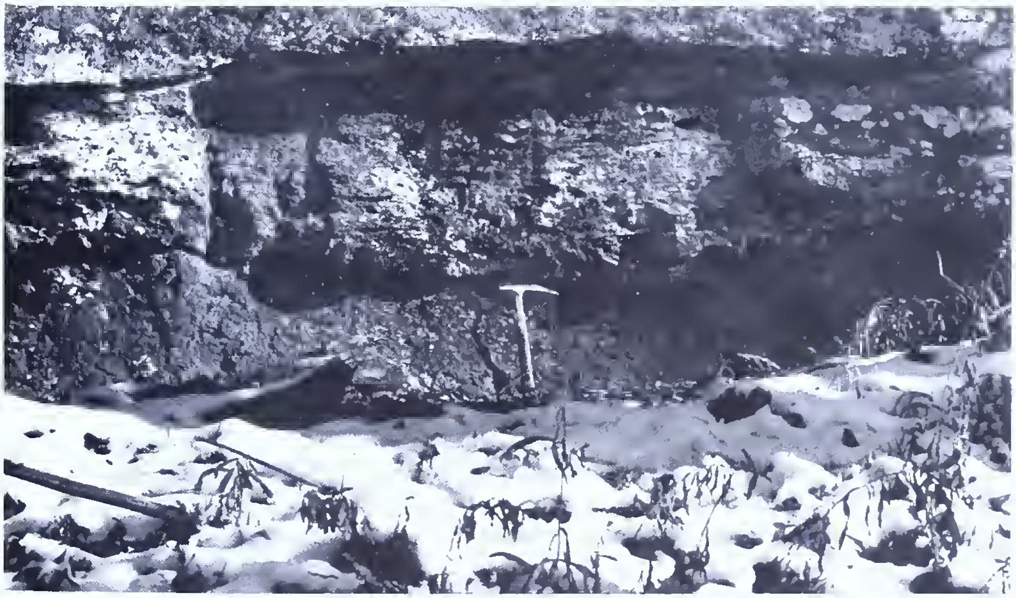

Figure 79. Base of reduced zone (at the head of the hammer), Upper Catskill Reduced Zone copper occurrence. The channel sample was cut in the malachite-bearing lowest 22 cm (9 in.) of calcareous breccia to the right of and above the hammer. Note that in this unprospected outcrop the calcareous breccia is more resistant to weathering than the underlying grayish-red mudstone, but less resistant than the overlying gray sandstone at the top of the photograph.

rence is described separately because of its lesser importance and distinct type. Because the U_3O_8 content at the Upper Catskill Reduced Zone copper occurrence is low, it is described only briefly to document the presence of typical copper-bearing calcareous breccia in the same reduced zone containing the more enticing "coal mine."

As determined from scattered malachite and slightly anomalous radioactivities, the occurrence can be traced for 14 m (46 ft) S50°E from the reference point. The "pseudo-adit" resulting from the fallen monolith is 1.8 m (5.9 ft) wide, 2.5 m (8.2 ft) deep, 0.8 m (2.6 ft) high at the back, and 1.7 m (5.6 ft) high at the entrance. Large fossil plant fragments, containing minor malachite and trace carbonaceous material, occur in the roof of the "pseudo-adit." This roof yields an average radioactivity of 300 cps and a radioactive assay of 60 ppm eU[1] for the exposed, reduced sandstone. The maximum radioactivity of the calcareous breccia, 500 cps, was observed at the base of the reduced zone 12 m (39 ft) southeast of the reference point.

The stratigraphy at the channel-sample site (Figure 79), located 5.3 m (17 ft) S50°E of the reference point, is described briefly in Table 61. In addition to the weakly mineralized, basal calcareous breccia described in this table, nearly barren calcareous breccias are abundant near the top of the reduced zone, just below the transitional colors.

Table 61. *Stratigraphic Section of Catskill Formation Rocks at the Upper Catskill Reduced Zone Copper Occurrence*

Exposure is an outcrop 5.3 m (17 ft) S50°E of the reference point.

Thickness (cm)	Radioactivity ("mR/hr")	Lithologic description
>200	.02	Between medium gray (N5) and medium dark gray (N4). Medium-grained, thin-bedded, crossbedded sandstone.
62	.03	Between medium gray (N5) and medium dark gray (N4). Thin- to medium-bedded, interbedded calcareous sandstone and calcareous breccia. This unit is moderately crossbedded, fills cutouts in the lower unit, and is almost missing at a site 4 m to N50°W. The 22-cm-thick, 0.04-"mR/hr" (average), assayed calcareous breccia sample is from the malachite-rich bottom portion of this unit.
>40	.03	Grayish-red (5R4/2) mudstone.

In this area, the reduced channel is believed to be not much more than 18 m (59 ft) thick, versus about a 3-m (100-ft) thickness at the Sheets "coal mine." This suggests that the Sheets "coal mine" is nearer the center of the input channel of this large reduced zone. Detailed sedimentologic studies would, however, be needed to substantiate this. Based on reconnaissance mapping by W. D. Sevon and others of the Pennsylvania Geological Survey, this reduced zone is about 120 m (400 ft) beneath the top of the Catskill Formation.

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[1] Based on comparisons of radiometric and chemical assays from other sites with geometric configurations similar to this site, the actual U_3O_8 content might be only 20±5 ppm U_3O_8.

NORTH MOUNTAIN CLUSTER

Jordan North Mountain Uranium Prospect 1

1. LOCATION:
   (a) The prospect is located on the Helen Burk property on the west flank of North Mountain at an approximate elevation of 442 m (1,450 ft). This is about 190 m (625 ft) east of Pa. Route 42, 2.12 km (1.32 mi) northwest of the intersection at the village of North Mountain, and 2.97 km (1.84 mi) southeast of Beech Glen, Davidson Township, Sullivan County.
   (b) Latitude: 41°18′22″N
   Longitude: 76°34′08″W
2. ASSAYS: A 13-cm (5-in.) channel sample of gray sandstone containing malachite on bedding partings yields 3 ppm U_3O_8 and 2,250 ppm copper. See sample MHK 749, Appendix 3.
3. MINERALOGY:
   (a) Major: None.
   (b) Minor: Malachite as thin coatings and micro-botryoids on bedding partings, and associated with carbonaceous plant fragments.
   (c) Trace: Barite as white to brown platy aggregates and crystalline masses on drusy quartz on a vertical joint in the northern mine pit; digenite(?) as disseminated grains in medium-grained sandstone that is partly oxidized to a peculiar "maroon" color; and calcite as off-white, crude micro-botryoids associated with malachite of similar habit.
4. GEOLOGIC DESCRIPTION: The prospect consists mainly of a small, unobtrusive excavation blasted from the hillside by John Jordan during the uranium boom of the 1950's. Jordan chose the site based on reconnaissance with a scintillometer. The small dump, located immediately west of the excavation, is quite lean; it took approximately one-half hour to find six slabs containing malachite and/or a radioactivity of 0.3 "mR/hr" on contact.

   The excavation exposed a reduced zone $\geq$ 1.4 m (4.6 ft) thick and $\geq$ 10 m (33 ft) long containing scattered, trace malachite. This outcrop is a medium-grained, crossbedded sandstone with 3- to 5-cm- (1- to 2-in.-) thick individual beds (Figure 80). Highly micaceous laminae are common. The 13-cm- (5-in.-) thick "ore zone" contains abundant malachite on bedding partings, but has an average radioactivity of only 0.05 "mR/hr." Within this 13-cm (5-in.) zone, there is a zone a few centimeters thick which contains disseminated blue and gray copper sulfides and irregular patches oxidized to a peculiar "maroon" color and which has a radioactivity of approximately 0.07 "mR/hr." The detailed stratigraphy exposed on the eastern face of the excavation is described in Table 62.

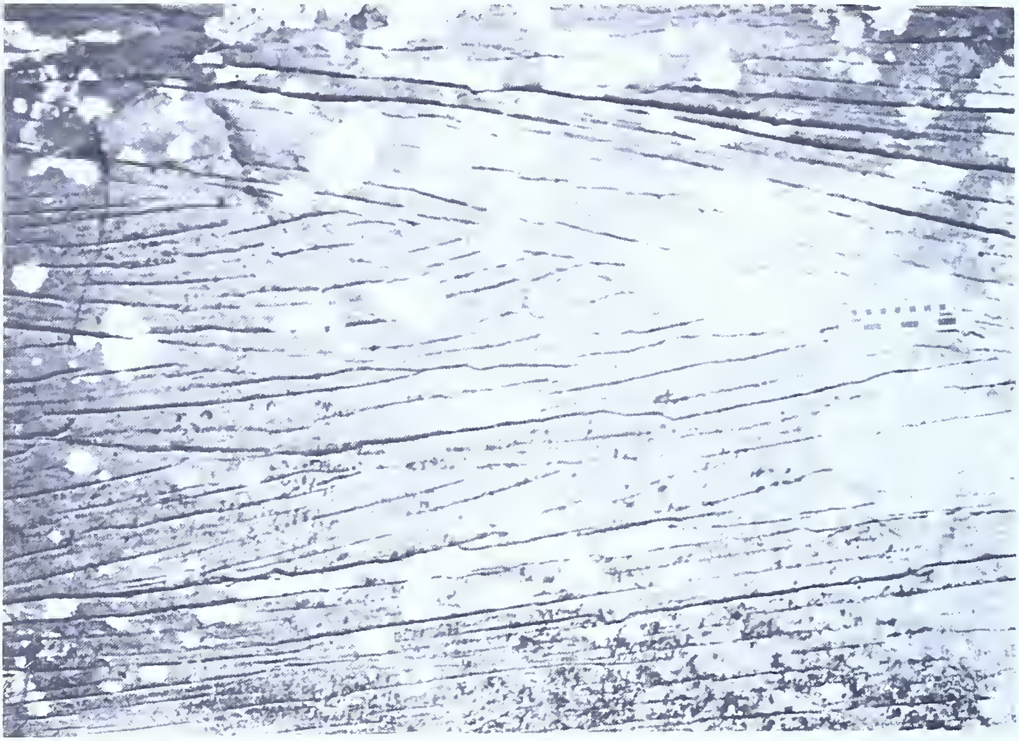

Figure 80. Medium-scale, cross-stratified sandstone of the Catskill Formation, dump area, Jordan North Mountain uranium prospect 1. Scale is 15 cm (6 in.) long.

Table 62. *Stratigraphic Section of Catskill Formation Rocks at Jordan North Mountain Uranium Prospect 1*

Exposure is on the east side of the prospect, approximately 3 km (2 mi) southeast of Beech Glen.

Thickness (cm)	Radioactivity ("mR/hr")	Lithologic description
>90	.02	Grayish-red (5R4/2) to blackish-red (5R2/2), medium-grained, thin-bedded, crossbedded sandstone.
23	.03	Medium-light-gray (N6) and medium-gray (N5), fine-grained, thin-bedded, crossbedded sandstone.
13	.05	Medium-light-gray (N6) to medium-gray (N5), medium-grained, thin-bedded, crossbedded sandstone with abundant malachite films on bed partings. Also trace disseminated malachite. Includes a few, centimeter-thick, medium-grained sandstone beds which are between grayish red (5R4/2) and blackish red (5R2/2) ("maroon") and contain shale chips. Muscovite is abundant on all observed bedding partings.
>40	.03	Greenish-gray (5GY6/1), medium-grained, thin-bedded, crossbedded sandstone. Includes one bed of medium-dark-gray (N4), medium-grained sandstone.

Fifteen meters (49 ft) to the north at the same horizon there is a tiny, 80- by 100-cm (30- by 40-in.) springlike pit in reduced sandstone. Here, carbonaceous plant fragments and malachite are more abundant, but the richest hand sample has a radioactivity of only 0.25 "mR/hr." White to brown barite on a N39°E-trending joint occurs on the northwest face of the tiny pit. At one time, prospected outcrop may have been nearly continuous between the two excavations.

Although the occurrence is of no direct economic significance, it is perhaps important in demonstrating mineralization this high in the Catskill Formation (approximately 150 m (500 ft) beneath the top), the apparent lack of a channel bottom containing calcareous breccia and phosphatic material, and the irregular distribution of "maroon" oxidation in a medium-grained, presumably once-porous, gray sandstone.

Jordan North Mountain Uranium Prospect 2

1. LOCATION:
   (a) The prospect is on the Helen Burk property on the west flank of North Mountain at an approximate elevation of 448 m (1,470 ft). This is about 270 m (900 ft) east of Pa. Route 42, 1.97 km (1.22 mi) northwest of the intersection at the village of North Mountain, and 3.12 km (1.94 mi) southeast of Beech Glen, Davidson Township, Sullivan County. Jordan North Mountain prospect 2 is about 125 m (410 ft) southeast of Jordan North Mountain prospect 1 and about 20 m (65 ft) higher in elevation.
   (b) Latitude: 41°18′21″N
   Longitude: 76°34′04″W
2. ASSAYS: A 22-cm (9-in.) channel sample of medium-grained gray sandstone containing carbonaceous plant fragments has 57 ppm U_3O_8 and 270 ppm copper. See sample MHK 732, Appendix 3.
3. MINERALOGY:
   (a) Major: None.
   (b) Minor: None.
   (c) Trace: Malachite as very rare, thin films and greenish pigmentations on bedding partings; "limonite" and golden-brown jarosite as coatings near traces of carbonaceous plant fragments; and pyrite as rare, partial replacements of carbonaceous plant fragments.
4. GEOLOGIC DESCRIPTION: The prospect consists of a small caved adit (Figure 81) dug by John Jordan during the uranium boom of the 1950's. The rock on the dumps is gray siltstone to very fine grained sandstone having an average radioactivity of only 0.02 "mR/hr." The maximum radioactivity observed on the dump is 0.04 "mR/hr."

   Limited exposure in the back of the caved adit shows the reduced zone to be ≥ 2.1 m (6.9 ft) thick and includes a 22-cm- (9-in.-) thick mineralized zone as described in Table 63. The color change at the top of the reduced zone is more gradational than at most occurrences.

Figure 81. Geologists in a collapse area above the former adit at Jordan North Mountain uranium prospect 2.

Table 63. *Stratigraphic Section of Catskill Formation Rocks at Jordan North Mountain Uranium Prospect 2*

Exposure is near the southeast corner of the caved adit.

Thickness (cm)	Radioactivity ("mR/hr")	Lithologic description
>100	.03	Between blackish red (5R2/2) and grayish red (5R4/2). Medium-grained, thin-bedded, crossbedded sandstone.
110	.03	Olive-gray (5Y4/1), medium-grained, thin- to medium-bedded, crossbedded sandstone.
22	.1	Olive-gray (5Y4/1), fine- to medium-grained, slightly micaceous, thin-bedded sandstone. This assayed unit contains abundant carbonaceous plant fragments and trace malachite.
>80	.03	Light-olive-gray (5Y5/2), medium-grained, slightly micaceous, thin-bedded, crossbedded sandstone which contains carbonaceous plant fragments.

In addition to being only about 150 m (500 ft) beneath the top of the Catskill Formation, the occurrence is unusual because of the lack of calcareous breccia, phosphatic fish remains, and highly micaceous layers, as well as the scarcity of copper mineralization.

OLD/NEW U.S. 220 CLUSTER

Bench Mark 359 Uranium-Copper-Lead Occurrence

1. LOCATION:
   (a) The occurrence is located at U.S. Geological Survey bench mark 359 at an elevation of 445 m (1,461 ft) on the northwest side of old U.S. Route 220, 1.73 km (1.08 mi) northeast of the confluence of Big Run and Mosey Run, Davidson Township, Sullivan County. The occurrence is adjacent to the Hit or Miss Hunting Club, about 100 m (330 ft) southwest along old U.S. Route 220 from the Laporte Township boundary, where the highway trends S62°W.
   (b) Latitude: 41°22′08″N
   Longitude: 76°32′08″W
2. ASSAYS: A 35-cm (14-in.) channel sample of "maroon," medium-grained sandstone from 1.6 m (5.2 ft) west of the bench mark, where the uraniferous zone is thickest, contains 339 ppm U_3O_8, 800 ppm copper, and 9,800 ppm (0.98 percent) lead.[1] A 60-cm (24-in.) channel sample of the underlying, more massive bedded, coarse-grained, gray sandstone contains 68 ppm U_3O_8, 470 ppm copper, and 800 ppm lead. See samples MHK 780 and 781, Appendix 3. A 9-cm (3.5-in.) channel sample of "maroon" and gray, medium-grained sandstone containing minor malachite and abundant carbonaceous matter, high-graded from 11 m (36 ft) northeast of the bench mark, has 743 ppm U_3O_8, 4,400 ppm copper, 555 ppm lead, approximately 15 ppm silver, 33 ppm molybdenum, 6 ppm selenium, and 820 ppm vanadium. See sample MHK 782, Appendix 3.
3. MINERALOGY[2]:
   (a) Major: "Limonite" as outcrop surface stainings, and as incrustations associated with subordinate black manganese oxide stainings on bedding partings in gray and "maroon" sandstone. Probable jarosite(?) is associated with the "limonite."
   (b) Minor: Malachite, most abundant in calcareous sandstone, as interstitial grains; coatings on bedding partings; halos surrounding "chalcocite" micrograins, shale chips, and phosphatic fish remains; and associated with carbonaceous plant fragments in "maroon" sandstone. Anglesite as white chalky coatings and prismatic microcrystals, which sometimes have limonitic surficial staining, on bedding and carbonaceous-plant-fragment partings in the limonitic zone.
   (c) Trace: "Chalcocite" as micrograins, and chrysocolla as rare blue-green interstitial micrograins and light-blue films on joint surfaces, all in calcareous sandstone; gypsum from underhangs as colorless to white films and microcrystals which fluoresce green (UV, short

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[1] To define the top of the sampled interval, a cutoff of 0.1 "mR/hr" was used, whereas the lower cutoff was at the change to more massive bedding.

[2] The majority of mineral descriptions are from samples collected 1.2 and 1.6 m (4 and 5 ft) west of the bench mark.

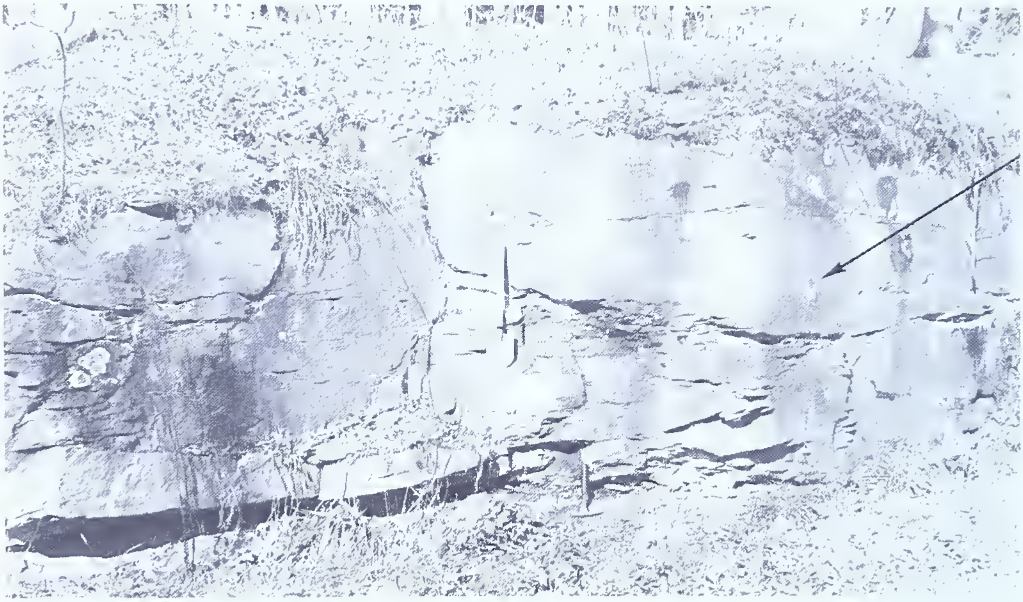

Figure 82. Site of channel samples MHK 780 and 781 and stratigraphic section, at the hammer; the head of the hammer is at the base of the reduced zone, Bench Mark 359 uranium-copper-lead occurrence. The bench mark is 1.6 m (5.2 ft) east, at the arrow.

wave); "apatite" as rare phosphatic fish remains in calcareous sandstone, and as a crossopterygian tooth in calcareous breccia; and rare granular pyrite in the limonitic zone.

4. GEOGRAPHIC DESCRIPTION: The occurrence consists of a 40-m- (131-ft-) long and $\geq$ 2.1-m- (6.9-ft-) thick, reduced fining-upward channel cut into a red mudstone. Of this length, 32 m (105 ft) is mineralized, based on scintillometer measurements (Table 64). The uraniferous zone has a typical thickness of approximately 25 cm (10 in.). Assuming the equivalent of a 30- by 10- by 0.2-m (100- by 33- by 0.7-ft) "ore zone" containing 100 ppm U_3O_8, 15 kg (33 lb) of U_3O_8 would be present at the occurrence.

   The occurrence appears to have the following characteristics: (1) the ratio of sandstone to calcareous breccia is relatively high; (2) the richest copper is in calcareous breccia-sandstone near the base of the reduced face; (3) the richest uranium is in medium-grained "maroon" sandstone approximately halfway up the exposed reduced face; and (4) carbonaceous plant fragments up to 3 by 25 cm (1 by 10 in.) are present in the medium-grained gray sandstone. The stratigraphy is described in Table 65. The location of the Bench Mark 359 uranium-copper-lead occurrence at the same elevation as the New U.S. Route 220 uranium-copper occurrences (p. 211), about 0.4 km (0.25 mi) to the south, and the small culvert occurrence (see below), about 15 m (50 ft) stratigraphically lower, make the occurrence interesting despite the low known "reserves."

   The culvert occurrence is located at utility pole C197, 0.26 km (0.16 mi) southwest along old U.S. Route 220 from bench mark 359. Here, the

Table 64. *Radiometric Measurements along the Best Uraniferous Horizons Exposed at the Bench Mark 359 Uranium-Copper-Lead Occurrence*

Located on the northwest side of Old U.S. Route 220.

	Location southwest of Bench Mark 359 (m)	(ft)	Radioactivity[1] (cps)	eU (ppm)	Comments
SW	13	43	<200		
	12	39	280		Slump block.
	11	36	450		Slump block.
	10	33	800		
	9	29	300		
	8	26	350		
	7	23	580		
	6	20	~600		Meter held in front of underhang.
	5	16	560		
	4	13	520	150	
	3	10	530	100	
	2	7	~800		
	1	3	1,250	275	Channel samples cut at 1.6 m (5.2 ft), the upper 35-cm (14-in.) interval of which yielded 600 ppm eU.
	0	0	1,250	550	
	1	3	540	70	
	2	7	700		Through vegetation.
	3	10	2,300	750	
	4	13	1,300		Through moss.
	5	16	900		Through moss.
	6	20	1,500		Through moss.
	7	23	700		Utility pole C190 alongside.
	8	26	550		Through soil and vegetation.
	9	29	300		Through soil and vegetation.
	10	33	400		Through soil and vegetation.
	11	36	2,800	1,450	Nine-centimeter (3.5-in.) "maroon" sandstone with radioactivity of 1 "mR/hr" (average).
	12	39	350	40	
	13	43	170		Through soil.
	14	46	250		
	15	49	160		Through soil.
	16	52	140		Through soil.
	17	56	120		Through soil.
	18	59	280		Through soil.
	19	62	400		Meter held in front of overhang. A small, leanly uraniferous "maroon" zone in this outcrop was examined and found to have a sharp contact between "red" and "gray" sandstone laterally within one bed; most of the malachite was in the "maroon" portion. This suggests that the "maroon" color is a reoxidation phenomenon.

Table 64. *(Continued)*

	Location southwest of Bench Mark 359 (m)	(ft)	Radioactivity[1] (cps)	eU (ppm)	Comments
	20	66	350		Meter held in front of overhang.
	21	69	220		Meter held in front of overhang.
	22	72	180		Meter held in front of overhang.
	23	75	140		Through soil.
	24	79	110		Through soil.
NE	25	82	100		Through soil. Area of last outcrop to northeast.

[1] Data were obtained with a Mt. Sopris SC–132 scintillometer and DGS, which typically yielded radiometric assays that are high by a factor of 2 in this area.

Table 65. *Stratigraphic Section of Catskill Formation Rocks at the Bench Mark 359 Uranium-Copper-Lead Occurrence*

Exposure is 1.6 m (5.2 ft) west of the bench mark (Figure 82).

Thickness (cm)	Radioactivity ("mR/hr")	Lithologic description
90	.03	Medium-gray (N5), fine- to medium-grained, thin- to medium-bedded, crossbedded sandstone. The unit is micaceous near the top.
18	.20	Between grayish red (5R4/2) and blackish red (5R2/2) ("maroon"). Sandstone containing a subordinate amount of medium-dark-gray (N4), medium-grained, medium-bedded sandstone with greenish-gray shale chips. The unit is lensoidal and intermittent, and shows a slight change in stratigraphic position along strike. This unit, and the 18-cm-thick unit below, make up the 35-cm-thick assayed sandstone sample.
18	.40	Between medium gray (N5) and medium dark gray (N4); contains minor "maroon" zones. Medium-grained, micaceous, thin-bedded sandstone. The unit is highly weathered, exhibits abundant limonitic and black manganese-oxide stainings, and contains abundant punky carbonaceous plant fragments. Pits, 2 to 20 mm in diameter, show remaining punky carbonaceous material, but might have included fine, granular pyrite.
55	.06	Medium-dark-gray (N4) sandstone; subordinate amount of medium- to coarse-grained, micaceous, medium-bedded, crossbedded sandstone which is between grayish red (5R4/2) and blackish red (5R2/2) ("maroon") and contains abundant medium-gray (N5) and medium-dark-gray (N4) shale chips. This assayed unit is calcareous in the bottom half and has notable amounts of "chalcocite" and malachite near the bottom. Minor calcareous breccia occurs near the base of the unit along strike.

Table 65. *(Continued)*

Thickness (cm)	Radioactivity ("mR/hr")	Lithologic description
33	.03	Between grayish olive green (5GY3/2) and dark greenish gray (5G4/1). Siltstone containing abundant dark-greenish-gray (5GY4/1) shale chips. The top 5 cm is included in the 60-cm-thick assayed sandstone sample.
>20	.03	Grayish-red (5R4/2) interbedded mudstone and siltstone.

road trends N35 °E past the exposures on the northwest side, which are also owned by the Hit or Miss Hunting Club. Trace copper and uranium mineralization occurs near the base of a well-exposed reduced zone estimated to be about 3 m (10 ft) thick. The length of discontinuous (because of soil cover) outcrop having a radioactivity of 200 cps is 12 m (39 ft). The richest spot yields 230 ppm eU, but the eU content drops off rapidly in less than 1 m (3 ft) in each of the exposed directions. The radioactivity within this spot is typically 0.15 "mR/hr," and there is an extremely localized area of 0.4 "mR/hr." Trace malachite occurs in greenish-gray shale in the road culvert, and a trace of disseminated "chalcocite" in gray, calcareous sandstone containing abundant shale chips was exposed near the base of the zone. The occurrence is of interest only in relation to the superposition of leanly mineralized reduced horizons in this area.

New U.S. Route 220 Uranium-Copper Occurrences

1. LOCATION:
   (a) The northeast and southwest occurrences are located in a large roadcut on the southeast side of new U.S. Route 220, between 75 and 85 m (245 and 280 ft) northeast of highway survey marker 3/50. The occurrences are 9.4 m (31 ft) apart (channel sample to channel sample) and essentially at road level,[1] 0.4 km (0.25 mi) south-southeast of bench mark 359 (elevation 445 m, or 1,460 ft) and 1.70 km (1.06 mi) northeast of the confluence of Big Run and Mosey Run, Davidson Township, Sullivan County. The occurrence can best be found by driving 1.70 miles (2.74 km) northeast on U.S. Route 220 from the cemetery entrance road on the northwest side of Sonestown.
   (b) Latitude: approximately 41°21′56″N[2]
   Longitude: approximately 76°32′02″W

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[1] When revisited in 1980, a lamina containing finely disseminated "chalcocite," trace malachite, barite, and zeunerite was observed at ditch level 27 m (89 ft) northeast of the main (southwest) lens. The lamina yielded 1,500 cps or 1.5 "mR/hr."

[2] Approximate because of the lack of precision of the available highway map and extensive revisions to the topography during road construction.

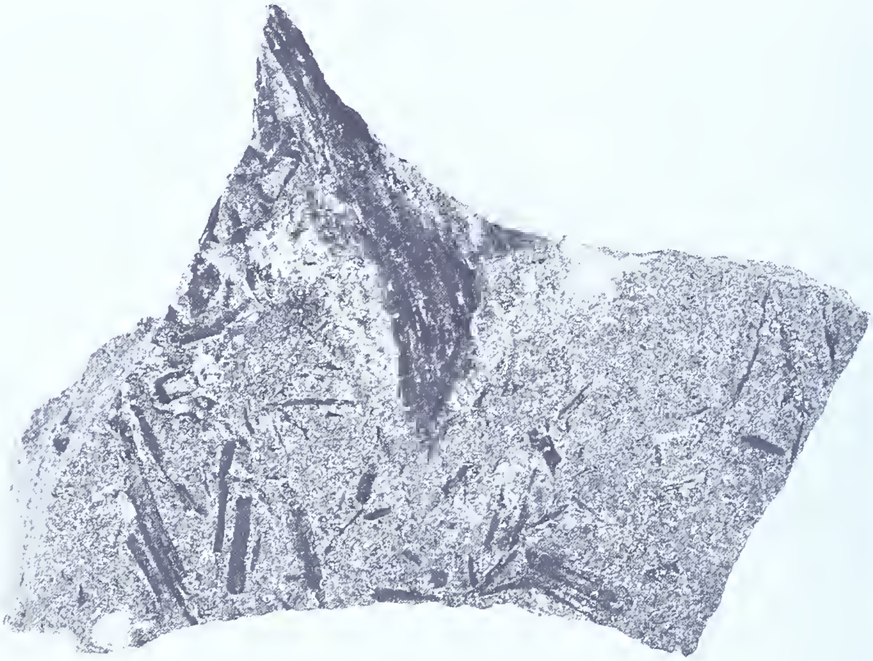

Figure 83. Carbonaceous plant fragments with malachite and a member of the meta-autunite group in micaceous gray sandstone, from the area of the New U.S. Route 220 uranium-copper occurrences.

2. ASSAYS: A 26-cm (10-in.) channel sample of micaceous gray sandstone and siltstone from the southwest channel-sample site contains 397 ppm U_3O_8, 7,000 ppm copper, and approximately 2,360 ppm barium. An 18-cm (7-in.) channel sample of gray sandstone containing carbonaceous plant fragments and some "maroon" mottling from the northeast channel-sample site has 978 ppm U_3O_8, 4,100 ppm copper, and approximately 3,150 ppm barium. See samples MHK 730 and 733, Appendix 3.
3. MINERALOGY:

   Southwest lens
   - (a) Major: Malachite, especially near carbonaceous plant fragments (Figure 83).
   - (b) Minor: Barite as clear, off-white, incomplete tabular crystals.
   - (c) Trace: Metatorbernite and metazeunerite as green, rectangular, micaceous crystals; wulfenite as clear, colorless tabular microcrystals on joints; a member of the meta-autunite group as yellow, powdery coatings associated with carbonaceous plant fragments; disseminated "chalcocite" in calcareous breccia; and apatite-group mineral as phosphatic fish remains in calcareous breccia.

   Northeast lens
   - (a) Major: None.
   - (b) Minor: Uranophane as dull-yellow coatings near carbonaceous plant fragments.
   - (c) Trace: Beta-uranophane as rare, fibrous, pale-yellow coatings which fluoresce pale greenish yellow (UV, short wave); metator-

Table 66. *Stratigraphic Section of Catskill Formation Rocks at the New U.S. Route 220 Uranium-Copper Occurrences, Southwest Lens*

Thickness (cm)	Radioactivity ("mR/hr")	Lithologic description
>33	.03	Medium-gray (N5) to medium-light-gray (N6), thick-bedded sandstone.
10	.16	Olive-gray (5Y3/2), highly micaceous siltstone containing abundant plant fragments. Included in assayed interval.
16	.12	Medium-dark-gray (N4), micaceous sandstone containing laminae of grayish-red (5R4/2) ("maroon") sandstone. Malachite is present on bedding surfaces. Included in assayed interval.
48	.02	Medium-light-gray (N6) sandstone containing a moderate amount of mica.
>38	.03	Medium-gray (N5) calcareous breccia that weathers to grayish red. Contains phosphatic fish remains and sparse disseminated "chalcocite."

bernite, metazeunerite, and meta-uranospinite(?) on bedding partings; and malachite.

4. GEOLOGIC DESCRIPTION: The closely related northeast and southwest occurrences are exposed in a large highway cut excavated for new U.S. Route 220 in the early 1970's. The first published description (Geyer and others, 1976) was based on information from D. T. Hoff. A

Table 67. *Stratigraphic Section of Catskill Formation Rocks at the New U.S. Route 220 Uranium-Copper Occurrences, Northeast Lens*

Thickness (cm)	Radioactivity ("mR/hr")	Lithologic description
30	.06	Medium-gray (N5) to olive-gray (5Y4/1), fine-grained, slightly micaceous sandstone.
19	.08	Brownish-gray (5YR4/1), fine-grained, mottled, slightly micaceous sandstone. Includes approximately 5 cm of grayish-olive-green (5GY3/2) siltstone-shale at the top.
13	.5	Olive-gray (5Y4/1), fine-grained, micaceous sandstone with brownish-gray (5YR4/1) mottling. Includes 4-cm-thick, dark-yellowish-brown (10YR4/2) lamina containing abundant plant fragments, minor yellow secondary uranium minerals, and trace malachite. This interval, plus the overlying 2 cm and underlying 4 cm of grayish-red (5R4/2)-mottled sandstone, is included in the assayed sample.
16	.08 (~.12 near top)	Medium-dark-gray (N4) to olive-gray (5Y4/1), fine-grained, micaceous sandstone with grayish-red (5R4/2) mottling.

vigorous growth of crown vetch prevents determination of the relationship between the two lenses. They may have been formed by one channel that meandered laterally with time. The northeast occurrence appears to be at a slightly lower stratigraphic level than the southwest occurrence. The stratigraphy at each occurrence is described in Tables 66 and 67. The lateral variations in stratigraphy are extreme.

The moderately high U_3O_8 contents, "maroon" sandstone, and possible stratigraphic relation to the Bench Mark 359 uranium-copper-lead occurrence, 0.4 km (0.25 mi) to the north-northwest, suggest that further study may be warranted.

MISCELLANEOUS OCCURRENCES

Allegheny Ridge Copper-Uranium Occurrence

1. LOCATION:
   (a) The occurrence is located in a 70-m- (230-ft-) long outcrop on the northeast side of Ticklish Rock Road, where the road trends N30°W, 0.24 km (0.15 mi) southeast of the intersection with Loyalsock Trail, Shrewsbury Township, Sullivan County. The visible mineralization is located 1.6 m (5 ft) above road level, here estimated to be at an elevation of approximately 523 m (1,715 ft), 0.21 km (0.13 mi) southeast of a bench mark at 516 m (1,693 ft). The occurrence is on the edge of the plateau, shown on the topographic map as Allegheny Ridge, which overlooks Muncy Creek valley.
   (b) Latitude: 41°21′14″N
   Longitude: 76°39′04″W
2. ASSAYS: A 45-cm (18-in.) channel sample of micaceous, medium-grained gray sandstone containing laminae rich in carbonaceous plant fragments has 10 ppm U_3O_8 and 500 ppm copper. See sample MHK 794, Appendix 3.
3. MINERALOGY:
   (a) Major: None.
   (b) Minor: None.
   (c) Trace: Malachite, especially intergrown with coarse muscovite flakes up to 2 mm; and barite in colorless cleavages on drusy quartz on joints in the sandstone near the top of the cut.
4. GEOLOGIC DESCRIPTION: This trace uranium and copper occurrence consists of a thin malachite-bearing horizon which has visible copper mineralization for only 1.3 m (4.3 ft) along strike. Typically, the malachite-stained horizon containing carbonaceous plant fragments is about 35 cm (14 in.) above the base of the reduced zone. The base of this reduced zone, lying on oxidized mudstone with about 1 m (3 ft) of erosional relief, is the provisional contact between the Upper Devonian Catskill Formation and the Upper Devonian-Lower Mississippian Huntley Mountain Formation (Figure 84). This is the youngest mineralized rock known in the area and suggests that the Mississippian sandstones above the Catskill Formation might be a suitable host for significant economic occurrences. Note also that the availability of trace uranium

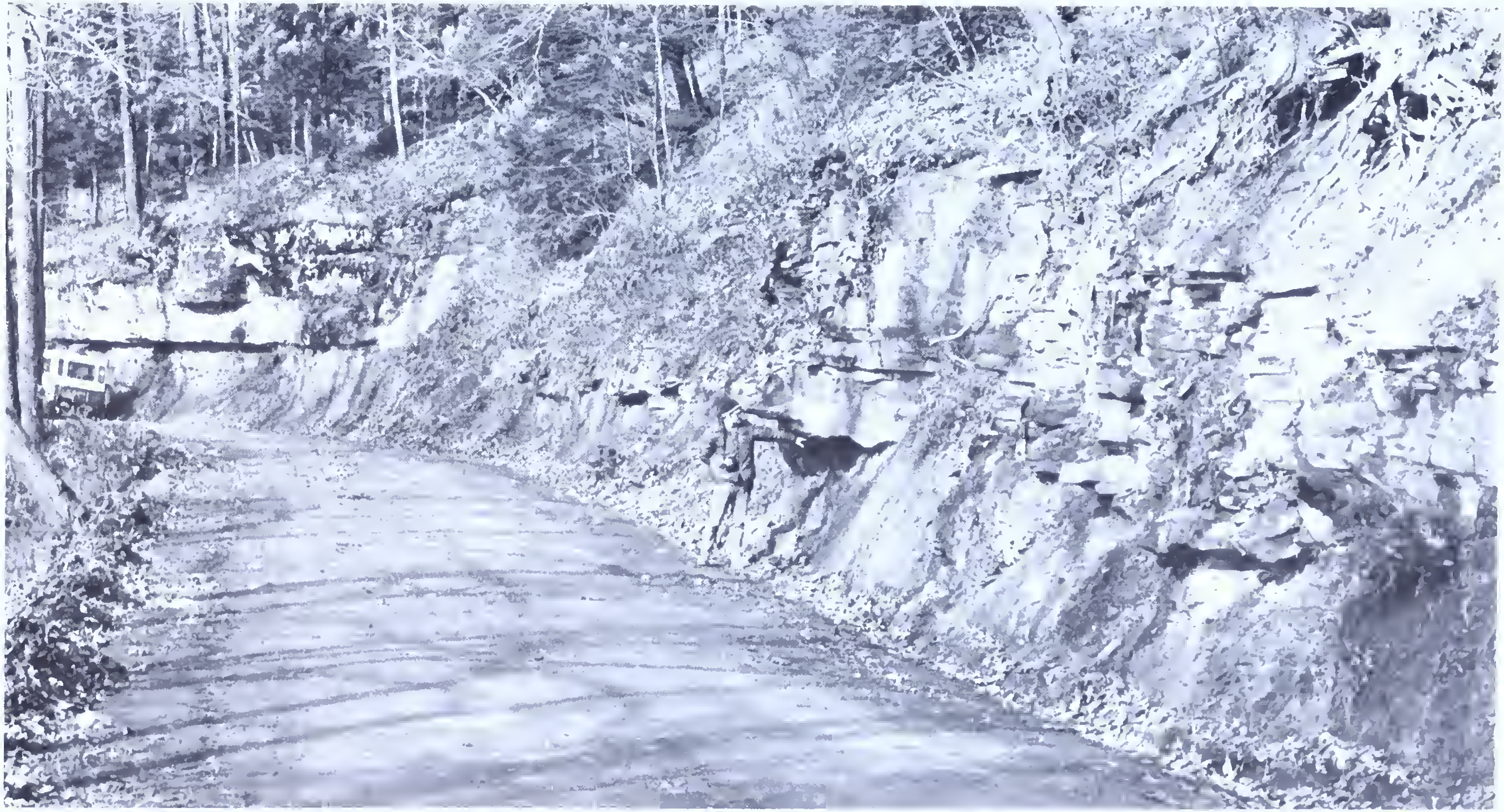

Figure 84. Apparent contact (at geologist's hand) between the overlying reduced sandstone of the Huntley Mountain Formation and the oxidized mudstone of the Catskill Formation, Allegheny Ridge copper-uranium occurrence. There appears to be about 1 m (3 ft) of erosional relief on this contact.

did not cease with the somewhat arbitrarily defined end of Catskill deposition. Indeed, some of the limonite-stained pockets of carbonaceous plant debris in the overlying reduced sandstones are slightly anomalously radioactive.

The stratigraphy 1 m (3 ft) north of the channel-sample site (Figure 85) is described in Table 68. The maximum radioactivity at this site is 170 cps and a radiometric assay there yields 25 ppm eU.[1] Elsewhere along the base of the reduced channel, away from the malachite, the radioactivity is only 150 cps and a radiometric assay yields 20 ppm eU.

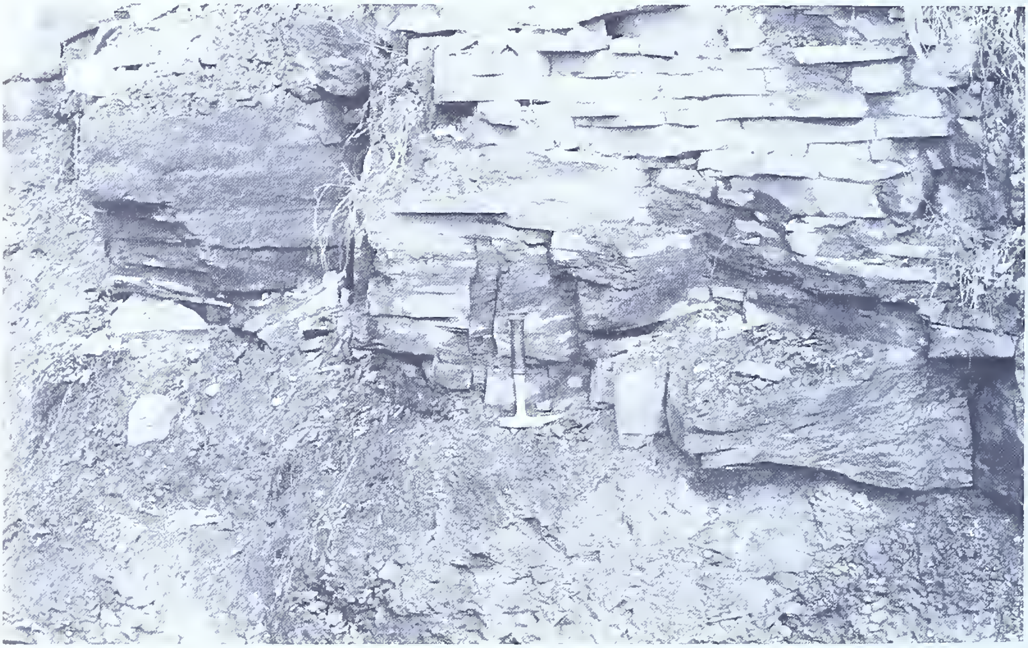

Figure 85. Cut for channel sample MHK 794, immediately to the left of the hammer, Allegheny Ridge copper-uranium occurrence. The 45-cm (18-in.) channel sample was cut from the apparent base of the Huntley Mountain Formation.

A few joints 0.5 to 1 m (1.5 to 3 ft) above the malachite-bearing horizon are coated with barite. These joints trend about N25°E, but the rocks may have slumped slightly. The presence of similar barite-coated joints at numerous unmineralized outcrops in the area suggests that there is no genetic connection between the uranium-copper and the barite.

The oxidized mudstone beneath the reduced sandstone contains numerous slickenside surfaces. The range of slickenside orientations is large, but surfaces tend to dip about 45°W. Some slickenside surfaces include a centimeter-wide reduced zone of greenish mudstone, possibly

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[1] Based on chemical assays, the field radiometric assay method yields uranium contents that are high by a factor of two times in the project area.

Table 68. *Stratigraphic Section of Huntley Mountain Formation Rocks at the Allegheny Ridge Copper-Uranium Occurrence*

Exposure is 1 m (3 ft) north of the channel-sample site.

Thickness (cm)	Radioactivity ("mR/hr")	Lithologic description
>100	.03	Dark-greenish-gray (5GY4/1), medium-grained, medium-bedded sandstone containing abundant grayish-red (5R4/2) shale chips. Crystalline barite occurs on joint surfaces.
85	.04	Dark-greenish-gray (5GY4/1), fine- to medium-grained, laminated to thin-bedded sandstone containing muscovite flakes up to 2 mm on bedding partings. The assayed sandstone sample was taken from the bottom 45 cm of the unit, which contains carbonaceous plant fragments and trace malachite.
7	.04	Dusky-yellow-green (5GY5/2) mudstone.
>130	.03	Grayish-red (5R4/2) mudstone which is highly brecciated and slickensided, and contains abundant dusky-yellow-green (5GY5/2) reduction zones along slickensides and as widely distributed blotches.

due to reducing solutions generated during deformation. Rather than indicating the trace of a major fault, these slickensides are probably due to the difference in competence between the sandstone and mudstone during regional folding.

Creekside Rod and Gun Club Prospects 1 and 2

1. LOCATION:
    (a) Creekside Rod and Gun Club Prospect 1 is located on the southeast side of a lane on the southeast side of Muncy Creek, 0.42 km (0.26 mi) southeast of the U.S. Route 220 bridge over Big Run in Tivoli (Dogtown), Penn Township, Lycoming County (Plate 1). Prospect 2 is 0.47 km (0.29 mi) southeast of the same bridge. (Prospect 2 is best located by proceeding 75 m (246 ft) from prospect 1 along the creekside trail in a S30°W direction and thence uphill 39 m (128 ft) in elevation to the southeast.)

	Prospect 1	Prospect 2
(b) Latitude:	41°17′46″N	41°17′44″N
Longitude:	76°41′16″W	76°41′15″W

2. ASSAYS: No samples were tested because of the low (<200 cps) readings obtained with the Mt. Sopris scintillometer and absence of visible copper mineralization.
3. MINERALOGY:
    (a) Major: Vitrain as carbonaceous plant fragments.
    (b) Minor: Jarosite(?) as thin, cream-colored coatings on fractures.

(c) Trace: Pyrite[1] as cylindrical areas up to 1 by 5 cm (0.4 by 2 in.) of distorted pyritohedrons and possibly as dodecahedral microcrystals in sandstone; and a clear, red, unidentified substance on a cleat set in vitrain.

4. GEOLOGIC DESCRIPTION: Prospect 1 consists of an open cut into a gray, fine-grained sandstone which contains large, vitrain-rich plant fragments in abundance, and cylindrical to lens-shaped pyrite nodules. The bottom of this open cut exposes a limestone containing marine invertebrate fossils, macerated carbonaceous plant debris, and trace pyrite. The outcrop along the trail approximately 120 m (400 ft) to the north-northeast consists of gray, fine-grained marine sandstone that may be coarser below the flat.

Prospect 2 consists of a caved adit with an area of subsidence extending a few meters uphill from the former entrance. Remains of wooden props and the moderate size of the dumps suggest that this was the result of a serious prospecting effort. The rock on the dumps consists of fine- to medium-grained, "rust"-stained, reduced sandstone containing abundant, large vitrain plant fragments. Those dump pieces that are calcareous also contain abundant marine fossil fragments, as does the outcrop near the base of the east side of the entrance.

Because of the abundance of anthracite-like plant fossils and the apparent lack of copper, uranium, and metallic minerals that could be mistaken for precious metals, it seems likely that the prospectors were in search of coal. Vegetation and weathering give the impression that the prospect is more than 50 years old.

Both Creekside Rod and Gun Club prospects 1 and 2 and the Rusty Logjam open cut 0.7 km (0.4 mi) to the northeast (see pages 217 and 81 and Plate 1) have been excavated in similar rocks by similar methods. The three prospects are of interest only to demonstrate the apparent absence of uranium and copper in reduced, plant-fragment-rich sandstones that have been strongly influenced by marine deposition. These are the stratigraphically lowest known prospects in the project area. They are slightly below the marine-transgression unit in the Catskill as mapped by Mahar (1978).

Creekside Rod and Gun Club Prospects 1 and 2 were brought to the authors' attention by Wilbur Mills of Hughesville.

Hill Family Reduced Zone Copper and Uranium Occurrences

1. LOCATION:

(a) Occurrence A is located at the base of a large, lightning-scarred white pine tree (*Pinus strobus*) on the north side of a west-north-

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[1] Presumably would be very abundant in unweathered samples.

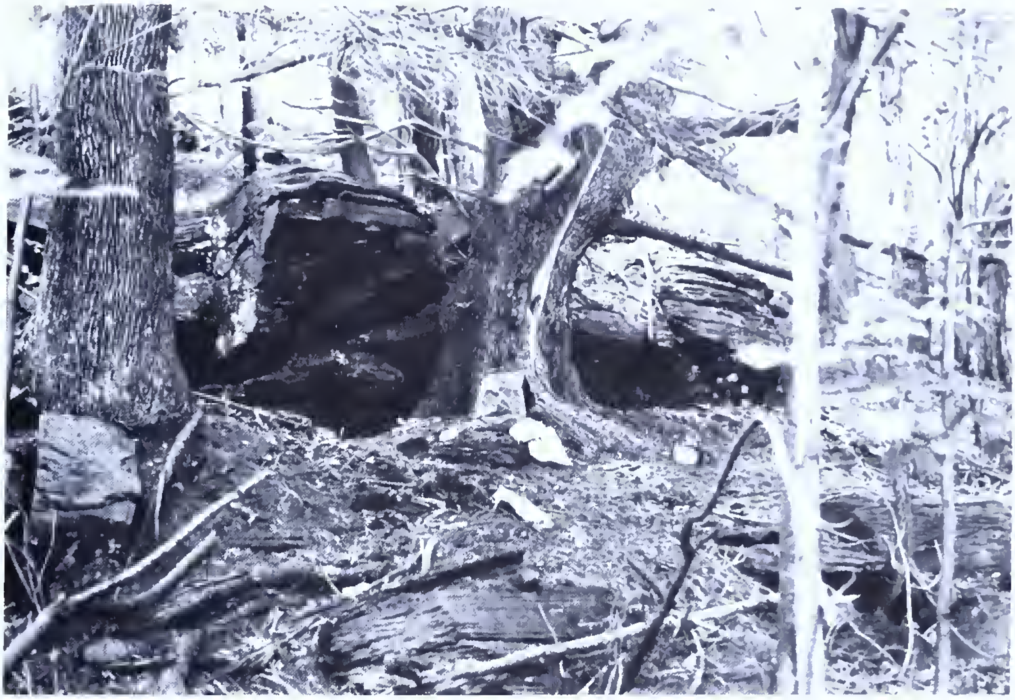

Figure 86. Occurrence A at the Hill Family Reduced Zone copper and uranium occurrences. Note the fresh lightning scar on the large white pine tree above the pack and sample bag. The 91-cm (36-in.) channel-sample (MHK 791) cut begins just to the left of the scarred tree and continues down, out of sight, where it was abandoned in mineralized rock because of thick roots.

west-trending jeep trail (Figure 86), 0.73 km (0.45 mi) west-northwest of a curve in Meyers Hill Road,[1] at an elevation of 356 m (1,170 ft), Penn Township, Lycoming County. This curve is 1.37 km (0.85 mi) north-northeast of the intersection with the Beaver Lake-Ebenezer Church road at an elevation of 368 m (1,209 ft). Occurrence A is on the south side of a saddle located just southwest of the pasture corresponding to the 1,200-foot (366-m) contour and 13 ± 1 m (43 ± 3 ft) below the high point in the pasture. This places occurrence A 2.85 km (1.8 mi) northwest of the outlet of Beaver Lake.

Occurrences B, C, and D can best be found by tracing the reduced outcrop southeast from occurrence A. The relative locations are given in Table 69 and shown on Plate 1.

All of the occurrences are on property owned by Stephen and Michael Hill.

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[1] This curve is also where the private jeep trail leaves Meyers Hill Road. The Cleon, Leon, Robert, and Willis Myers families who reside in this area suggest that the spelling "Meyers" used on township road signs is inappropriate.

Table 69. ***Relative Locations of Copper and Uranium Occurrences at the Hill Family Reduced Zone Site***

Zone is 2.8 km (1.7 mi) northwest of the outlet of Beaver Lake.

From occurrence	To occurrence	Distance and bearing to next occurrence to the southeast
A	B	55 m (180 ft) S26°E
B	C	28 m (92 ft) S
C	D	142 m (466 ft) S22°E

	Occurrence A	Occurrence B	Occurrence C	Occurrence D
(b) Latitude:	41°18′08″N	41°18′07″N	41°18′05″N	41°18′02″N
Longitude:	76°37′22″W	76°37′21″W	76°37′21″W	76°37′18″W

2. ASSAYS: A 91-cm (36-in.) channel sample of micaceous, calcareous, gray sandstone containing carbonaceous plant fragments, malachite, and "chalcocite" at the occurrence A outcrop yields 70 ppm U_3O_8, 3,000 ppm copper, 2,000 ppm lead, and approximately 20 ppm silver. The mineralized zone is greater than 91 cm (36 in.) thick, but the channel sample could not be continued to the bottom because of thick tree roots. See sample MHK 791, Appendix 3.
3. MINERALOGY:
   (a) Major: Malachite as interstitial grains, also crusts and microbotryoids, sometimes with a velvety surface, on bedding partings and in and near carbonaceous plant fragments, all in reduced sandstone; and as grains in weathered calcareous breccia.
   (b) Minor: "Chalcocite" as micrograins in lower, reduced, calcareous sandstone; and pistachio-green micrograins of an unknown affinity in reduced sandstone.
   (c) Trace: Chrysocolla as olive-green to blue-green crusts on bedding partings and carbonaceous plant fragments, and azurite as rare interstitial micrograins, all in reduced sandstone; and chalcopyrite, bornite, and covellite(?) as micrograins associated with the "chalcocite."
4. GEOLOGIC DESCRIPTION: The Hill Family Reduced Zone copper and uranium occurrences are exposed in largely natural outcrops over a length of approximately 200 m (650 ft). The reduced zone is about 2 m (7 ft) thick, but is typically barren (100 to 150 cps). It can be traced substantially farther to the west, but appears to be unmineralized where examined. Only occurrence D showed signs of minor, probable prospecting in the form of slight undercutting of the outcrop. The grade and thickness of each occurrence are presented in Table 70. A stratigraphic description of occurrence A is given in Table 71.

   The best observed mineralization is at occurrence A. This occurrence is bounded on the east by a large white pine tree bearing a distinctive lightning scar and on the west by a large maple tree. Drywall a few

Table 70. *Summary of Mineralized Occurrences at the Hill Family Reduced Zone Site*

Zone is approximately 2.8 km (1.7 mi) northwest of the outlet of Beaver Lake.

Occurrence	Thickness of reduced zone	Thickness ≥ 200 cps	Discontinuous length ≥ 200 cps	Gross maximum cps	Typical ppm eU
A	≥ 3.2 m (10.5 ft)	~3 m (10 ft)	~6 m (20 ft)	~1,000	140
B	≥ 2.1 m (6.9 ft)	.8 m (2.6 ft)	5 m (16 ft)	1,100	100
C	≥ 2.0 m (6.6 ft)	≥ .5 m (1.6 ft)	6 m (20 ft)	1,300	50
D	≥ 2.0 m (6.6 ft)	≥ .8 m (2.6 ft) (at undercut)	22 m (72 ft) (to south from undercut)	400 (in under-cut)	50 (to south from undercut)

meters northwest of the site of the channel sample and stratigraphic description could be filling in an old copper prospect. The next outcrop to the northwest (8 m (26 ft) from the channel-sample site) yields a maximum radioactivity of 350 cps, suggesting that the mineralization proba-

Table 71. *Stratigraphic Section of Catskill Formation Rocks at the Hill Family Reduced Zone Copper and Uranium Occurrence A*

Exposure is 1 m (3 ft) west of the center of the 6-m- (20-ft-) long (strike length) radioactive outcrop, at occurrence A.

Thickness (cm)	Radioactivity ("mR/hr")	Lithologic description
>120	.05	Grayish-red (5R4/2), fine-grained, micaceous, laminated to thin-bedded, crossbedded sandstone which is calcareous near the bottom.
21	.06	Grayish-red (5R4/2) calcareous breccia.
30	.13	Medium-light-gray (N6) to medium-dark-gray (N4), fine- to medium-grained, micaceous, thin-bedded, crossbedded sandstone which is calcareous and contains several thin beds of weathered calcareous breccia with malachite. The unit is punky and very dark brown where calcite has weathered; it contains malachite coatings on bedding partings throughout, and has carbonaceous plant fragments in the bottom half. This unit makes up the top third of the 91-cm-thick assayed sample.
62	.18	Medium-gray (N5) to medium-dark-gray (N4), fine- to medium-grained, micaceous, thin-bedded sandstone containing a 14-cm-thick bed of calcareous breccia 21 cm below the top. The unit contains abundant malachite throughout, and a 3-cm-thick zone rich in carbonaceous plant fragments immediately below the calcareous breccia. The lower 24 cm contains calcareous zones with "chalcocite." The lowest unit interval was not described due to excavation difficulties.

bly extends beneath the drywall. Vertical joints at occurrence A trend N32°E. The base of the reduced zone at this outcrop could not be exposed with crack hammer, chisels, and pry bar. Where the channel sample was discontinued, the rock was moderately mineralized with uranium and disseminated "chalcocite," as was the lower third of the excavation.

Because it was never properly tested and is partly exposed over several acres (a few hectares), this reduced zone is worthy of further study by geochemical and geophysical methods. A detailed study of bedding attitudes, difficult because of crossbedding in all but the mudstones, is also recommended.

Klemic Locality 6 Copper Occurrence

1. LOCATION:
   (a) The occurrence is in a large slump block, presently (1979) located 16 m (52 ft) east-southeast of the Tivoli adit (p. 228) and 2.5 m (8 ft) lower in elevation.[1] The base of the block is 3.5 m (11.5 ft) in elevation above the level of a northwest-trending private driveway on the north side of Big Run. This driveway leaves U.S. Route 220 30 m (98 ft) northeast of the steel bridge in Tivoli (Dogtown), Shrewsbury Township, Lycoming County (Plate 1). The slump block is approximately 0.13 km (0.08 mi) northwest of the steel bridge.
   (b) Latitude: 41°17′56″N
   Longitude: 76°41′37″W
2. ASSAYS: No samples were taken because the mineralization was not located *in situ*. Float suggests less than 25 ppm U_3O_8 and less than 0.2 percent copper.
3. MINERALOGY:
   (a) Major: None.
   (b) Minor: None.
   (c) Trace: Malachite on bedding partings in micaceous, gray siltstone.
4. GEOLOGIC DESCRIPTION: Although the occurrence is presumably very low stratigraphically, it was not studied in detail because of the lean nature of the available float. A brief search of the base of the sheer bluff also suggested that the discovery of *in situ* mineralization would not be easy.

   The slump block at Klemic locality 6 is approximately 7 m (23 ft) long across the base and of approximately the same height. Malachite stains on red and gray siltstone float downslope from the block were traced to the western end of the block, where trace malachite occurs "*in situ*" at the extreme base of the block. The host to the malachite here is a micaceous gray siltstone which has a radioactivity of only 200 cps on contact, barely above background for such a geometry.

   If the block has not slumped far downslope, this trace copper-uranium occurrence could have come from rock below or within the marine-transgression unit in the lower Catskill Formation as mapped by

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[1] The present rate of downslope movement has not been determined.

Mahar (1978). Klemic (1962, p. 277) reported brachiopod fossils at the occurrence. Also, the Tivoli adit, located 16 m (52 ft) to the west-northwest, contains definite marine limestones *in situ*. The Tivoli adit, however, does not contain any uranium or copper mineralization.

If copper mineralization can be found *in situ*, detailed sedimentological and geochemical studies should be undertaken to provide further insights into the genesis of the copper-uranium occurrences that are higher in the Catskill Formation and have more economic potential.

Marquardt Copper and Uranium Occurrences

1. LOCATION:
   (a) The occurrences are on the Robert Marquardt property, in outcrops on the northwest side of the unnamed secondary road that trends north from Strawbridge along Spring Run. They are at points 207 m (679 ft) (copper) and 242 m (794 ft) (uranium) northeast of the intersection with Krause's Road, Shrewsbury Township, Sullivan County. The uranium occurrence is 5.2 m (17 ft) lower in elevation than the large flat shown at 488 m (1,600 ft) on Plate 1. The copper occurrence is estimated to be at an elevation of 485 m (1,590 ft). This area is 2.03 km (1.3 mi) northwest of the bridge of U.S Route 220 over Muncy Creek in Muncy Valley.

	Marquardt copper occurrence	Marquardt uranium occurrence	Drill hole E
(b) Latitude:	41°21′14″N	41°21′14″N	41°21′12″N
Longitude:	76°36′21″W	76°36′20″W	76°36′23″W

2. ASSAYS: An 8-cm (3-in.) channel sample of medium-grained, gray sandstone containing trace malachite from the copper occurrence has 4 ppm U_3O_8 and 900 ppm copper. See sample PRS–2, Appendix 3. A 26-cm (10-in.) channel sample of gray sandstone from the uranium occurrence containing carbonaceous plant fragments and yellow-brown ochre has 14 ppm U_3O_8, 265 ppm copper, 250 ppm arsenic, and 7,800 ppm lead. See sample PRS–8, Appendix 3.
3. MINERALOGY:

Copper occurrence

(a) Major: None.

(b) Minor: Malachite as fine-grained disseminations and crusts on carbonaceous plant fragments.

(c) Trace: Thin, bright-orange weathering rind similar to that found in the Middle Catskill reduced zone. Chalcopyrite as disseminated grains in sandstone.

Uranium occurrence

(a) Major: None.

(b) Minor: Plumbojarosite(?) as orange-brown earthy coating associated with carbonaceous plant fragments.

(c) Trace: None.

Northwest roadside borrow pit

(a) Major: None.

(b) Minor: Zoned white barite, wad, and drusy quartz on joints.
(c) Trace: None.

4. GEOLOGIC DESCRIPTION: Trace mineralization in this portion of the Robert Marquardt property was observed in two natural outcrops, a roadside borrow pit, and possibly in chips from a rotary drill hole.

Robert Marquardt (personal communication, November 9, 1979) reported that Wieand Brothers, of Milton, Pennsylvania, drilled several deep holes in search of uranium on his property. The drilling was reported to have been financed by a major oil company with Marquardt's permission. Plate 1 shows five hole locations that Marquardt provided. Chips at hole E yielded a radiometric assay of 20 ppm eU (suggesting on the order of about 10 ppm actual U_3O_8 based on other sites in the project area) versus 10 to 15 ppm eU (or about 5 to 8 ppm) at the other four chip piles. The chips at hole E consisted of oxidized, micaceous siltstone and fine-grained sandstone and $\leq$ 10 percent reduced, micaceous, fine- to medium-grained sandstone. A few slightly pink chips appear to contain feldspar. Based on the somewhat anomalous radiometric assay of the bulk chip pile, it is assumed that some uranium mineralization was encountered.

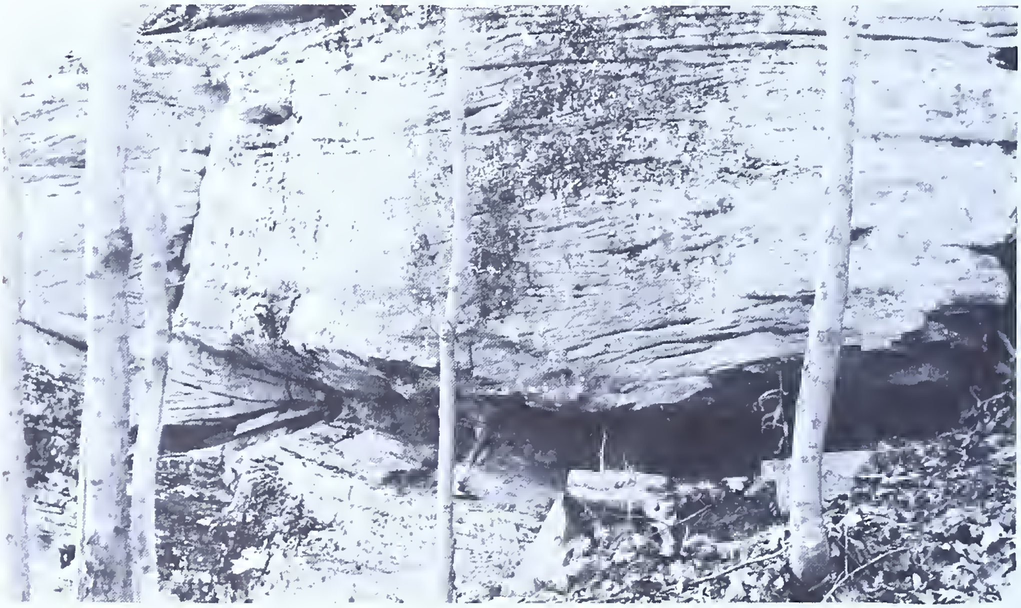

Figure 87. Cut for channel sample PRS–8 and stratigraphic-description site, Marquardt uranium occurrence. Twenty-six centimeters (10 in.) of gray sandstone containing plumbojarosite(?) was collected immediately to the left of the hammer. The apparent accelerated weathering and jarosite-group mineral suggest that some primary pyrite was present. Note the trough crossbedding to the left.

Mineralization in the roadside borrow pit is limited to [illegible] joints in the southwest corner. This area is on the northwest side of the same paved road 300 m (1,000 ft) northeast of its intersection with Krause's Road. At the southwest end of the borrowed area, a maximum thickness of 4.15 m (13.6 ft) was measured for the reduced zone. In this area, the basal contact has up to 70 cm (28 in.) of relief.

The copper occurrence consists of an outcrop of thin-bedded, crossbedded, medium-grained gray sandstone containing sparse carbonaceous plant fragments, malachite, and trace chalcopyrite. The thickness of copper mineralization is about 10 cm (4 in.) and the lateral extent is ≥ 1.7 m (5.6 ft). The sandstone has a bright-reddish-orange weathering rind near the copper. There is an additional 0.45 m (1.5 ft) of reduced rock above the copper zone and ≥ 1 m (3 ft) below, so that the total thickness of reduced rock is approximately 1.5 m (4.9 ft) or more.

Thirty-five meters (115 ft) to the northeast of the copper occurrence is a zone that has lean uranium mineralization. This uranium occurrence consists of an approximately 20 cm (8 in.) thick by 10 m (33 ft) long zone yielding ≥ 200 cps. A slight underhang where carbonaceous plant fragments and "jarosite" staining occur yields 300 cps and 50 ppm eU (Figure 87). The lithologies at the channel-sample site are described in Table 72.

Table 72. *Stratigraphic Section of Catskill Formation Rocks at the Marquardt Uranium Occurrence*

Exposure is at the channel-sample site.

Thickness (cm)	Radioactivity ("mR/hr")	Lithologic description
>100	.03	Grayish-red (5R4/2), fine-grained, thin-bedded, crossbedded sandstone.
200	.03	Medium-gray (N5), medium-grained, thin-bedded, crossbedded sandstone. The color of the unit is transitional to grayish red (5R4/2) near the top.
28	.05 .09 max.	Between light gray (N7) and medium light gray (N6). Medium-grained, laminated to thin-bedded sandstone. The unit exhibits disturbed bedding, and the upper 26 cm, which was assayed, contains abundant carbonaceous plant fragments and brown to yellow-brown weathering products.
>80	.03	Medium-gray (N5), medium-grained, thin-bedded, crossbedded sandstone.

The occurrences are of no direct economic significance, but are very important in demonstrating the presence of copper, uranium, and lead in Catskill sandstones within approximately 50 m (165 ft) of the upper contact.

McCauley Prospect 17

1. LOCATION:
   - (a) The center of this former prospect is located on the Weston family property 39 m (128 ft) N43°W of the center of a north-northeast–south-southwest trending secondary road. This is 2.39 km (1.48 mi) southeast of the outlet of Beaver Lake, 2.64 km (1.6 mi) southwest of the intersection at the village of North Mountain, and 1.53 km (0.95 mi) northeast of the confluence of Beaver Run and Marsh Run, Franklin Township, Lycoming County. The pit center is 29 m (95 ft) N53°W of the building shown on the topographic map at an elevation of approximately 363 m (1,190 ft).
   - (b) Latitude: 41°16′34″N
     Longitude: 76°34′34″W
2. ASSAYS: No channel samples were collected because the exposed ore zone receives direct effluent from an outhouse without benefit of soil filtration. A 3.5-kg (7.7-lb) composite of approximately 2.5 cm (1 in.) chips of reduced rock containing trace malachite or carbonaceous plant fragments or calcareous breccia has 340 ppm U_3O_8, 4,950 ppm copper, and 190 ppm arsenic. As collected, the sample bag had an average radioactivity of 0.1 "mR/hr," versus 0.08 ± 0.02 for the whole dump. See sample MHK 731, Appendix 3.
3. MINERALOGY:
   - (a) Major: Malachite as crusts, micro-botryoids, and radiated to stellated groups of acicular microcrystals on bedding partings.
   - (b) Minor: Azurite as microcrystals; olivenite as silky coatings of white fibers, beudantite(?) as golden-brown coatings on sandstone, and opal (variety hyalite) as fluorescent coatings, all on bedding partings; and unidentified pistachio-green "BB's" in sandstone.[1]
   - (c) Trace: Metazeunerite as rectangular, micaceous, platy to pyramidal, apple-green crystals up to approximately 1 mm; rare "chalcocite" as tiny disseminated blebs, and associated with covellite(?) as a partial replacement of a carbonaceous plant fragment; rare tyrolite as radiated bluish-green crystal sprays up to 7 mm on sandstone; barite as clear, colorless tabular microcrystals; rare uranophane as pale-yellow, acicular microcrystals; "apatite" as phosphatic fish remains; and chrysocolla.
4. GEOLOGIC DESCRIPTION: The prospect formerly consisted of an 11-m- (36-ft-) long (east-west) and 9-m- (30-ft-) wide pit with a mineralized dump on the south side. The dump, however, was recently bulldozed into the pit. The backfilled pit now yields an average radioactivity of 0.08 ± 0.02 "mR/hr," or 700 ± 200 cps, as the former dump did.

   A 5-m- (16-ft-) long and 2.3-m- (7.5-ft-) high outcrop remains directly downslope from the outhouse on the north pit rim (Figure 88). This outcrop is 5 m (16 ft) north of the former pit center. The average radioactivity of reduced rock in this outcrop is 0.08 "mR/hr," or 400 cps, and the maximae are 0.2 "mR/hr" and 1,800 cps. The exposed thickness of

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[1] In thin section these grains are deep olive green and are nearly isotropic.

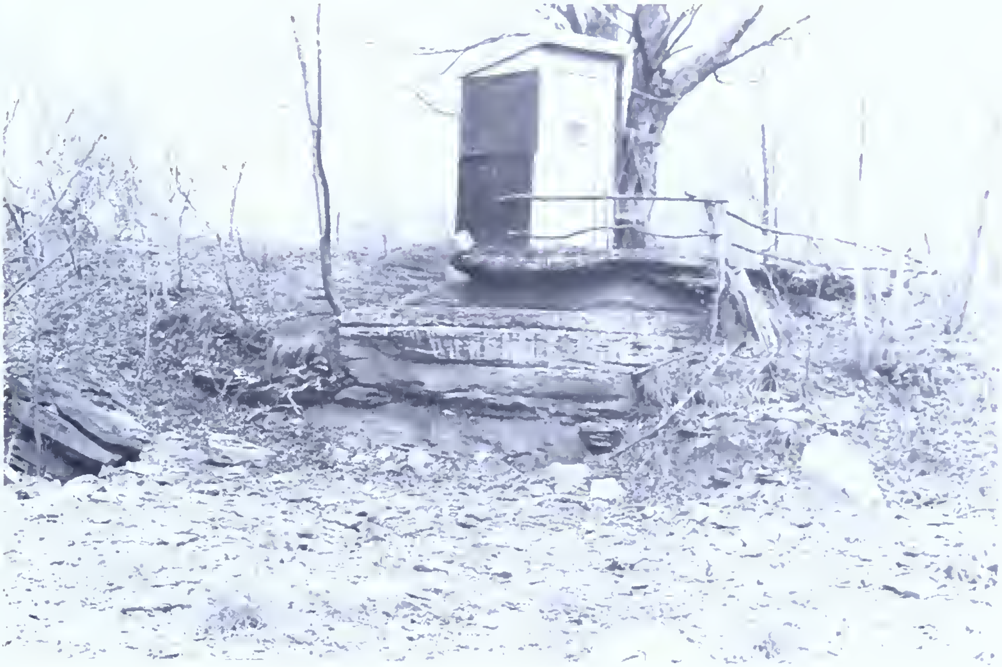

Figure 88. Recently bulldozed pit (foreground) and leanly mineralized outcrop 5 m (16 ft) north of the former pit center, McCauley prospect 17. Sample MHK 731 was taken from the area in the foreground.

reduced rock at the outcrop is more than 1 m (3 ft). This reduced rock consists of flaggy, thin-bedded, fine-grained, gray sandstone. The top of the reduced zone here is transitional in color and the exposed mineralized horizon is 25 cm (10 in.) below the top of the reduced zone.

From 12 to 19 m (39 to 62 ft) S80°W of the center of the former pit, there are discontinuous exposures of reduced rock. The average radioactivity of these outcrops is 0.05 "mR/hr," and the average radiometric assay is 30 ppm eU. The exposed thickness of reduced rock is $\geq$ 2.7 m (8.8 ft), the top being well defined. The base is indicated only by float of calcareous breccia containing malachite, carbonaceous plant fragments, and phosphatic fish remains. The reduced rock consists of flaggy, thin-bedded, fine-grained, gray sandstone. One small area 15 m (50 ft) N88°W of the old pit center and 50 cm (20 in.) below the top of the reduced zone contains carbonaceous plant fragments associated with copious, thin, beudantite(?) coatings on bedding partings. The average radioactivity in this area is 0.14 "mR/hr," and a radiometric assay yields 400 ppm eU.

Several bulldozer scrapings on the northwest side of the road on the same property do not appear to have exposed reduced rock. Similarly, residents of the area reported that drill holes to the northeast yielded only oxidized rock. Despite the limited lateral extent, the grade of the dump and thickness of reduced rock make this one of the more interesting lenses in the lower Catskill Formation. W. D. Sevon (personal communication, 1978) noted an *Archanodon* fossil in a large boulder on the dump. According to Sevon, the modern analogs of *Archanodon* are nonmarine species. This fossil is similar to the better preserved one from the Hamilton-Jordan uranium-copper prospect, shown in Figure 45 and color photograph 29.

Tivoli Adit

1. LOCATION:
   (a) The adit is located 0.15 km (0.09 mi) N44°W of the steel bridge of U.S. Route 220 in Tivoli (Dogtown), Shrewsbury Township, Lycoming County. The entrance is 6 m (20 ft) in elevation above a private lane, 0.12 km (0.07 mi) west-northwest of its intersection with U.S. Route 220 and 86 m (280 ft) east of the house. Klemic locality 6 is presently located 16 m (52 ft) to the east-southeast.
   (b) Latitude: 41°17′56″N
   Longitude: 76°41′38″W
2. ASSAYS: A 52-cm (20-in.) channel sample of pyritic, calcareous sandstone containing carbonaceous plant fragments and brachiopod fragments has 3 ppm U_3O_8, 25 ppm copper, and 180 ppm arsenic. A 23-cm (9-in.) channel sample of the underlying pyritic limestone containing brachiopods and carbonaceous plant fragments has 2 ppm U_3O_8, 20 ppm copper, and 50 ppm arsenic. A radiometric assay of this unit in the field yielded an estimate of 5 to 10 ppm U_3O_8. See samples MHK 788 and 789, Appendix 3.
3. MINERALOGY:
   (a) Major: Pyrite as granular aggregates.
   (b) Minor: Gypsum as white to iron-stained crusts in underhangs and in the adit.
   (c) Trace: Arsenopyrite as prismatic crystals, including star-shaped trilling twins.
4. GEOLOGIC DESCRIPTION: The Tivoli adit, perhaps one of the most mysterious in the district, may have been excavated by the same group who excavated the Rusty Logjam open cut, located 0.9 km (0.6 mi) to the northeast, and the Creekside Rod and Gun Club prospects 1 and 2, located 0.6 km (0.37 mi) to the southeast. It is not known what commodity was sought at these prospects. Some of the possibilities include: (a) coal, based on the large, abundant carbonaceous plant fragments and limb casts; (b) limestone, based on the limestone layers and verified limestone quarry in the Catskill Formation at Millview, Sullivan County (Smith, 1977b, p. 221); or (c) silver and/or lead, based on a possible mistaken identity of the trace arsenopyrite. Copper prospecting can probably be ruled out because of the complete lack of copper bloom at the outcrop and the slumped nature of the cupriferous Klemic locality 6 outcrop 16 m (52 ft) to the east-southeast. Uranium can be ruled out based on the age of these prospects, probably more than 50 years. The occurrence is included in this study despite the lack of copper and uranium because (a) it documents a marine occurrence of arsenic in the lower Catskill For-

Table 73. ***Stratigraphic Section of Catskill Formation Rocks at Tivoli Adit***

Exposure is on the east side of the entrance to the adit.

Thickness (cm)	Radioactivity ("mR/hr")	Lithologic description
>30	.03	Olive-gray (5Y3/2) shale.
29	.03	Medium-dark-gray (N4), laminated siltstone and fine-grained sandstone. The unit is slightly calcareous and contains abundant "limonite" blotches near the top.
55	.03	Medium-gray (N5), fine-grained, calcareous and pyritic, thin-bedded sandstone which contains carbonaceous plant fragments, including large logs in the roof of the adit. A 3-cm-thick calcareous sandstone bed containing complete and broken brachiopod fossils, pyrite micrograins, and arsenopyrite microcrystals occurs 10 cm below the top of the unit; a 2-cm-thick, medium-gray (N5) shale zone occurs immediately below this arsenopyrite-bearing sandstone bed. Weathered surfaces in this unit are extremely limonitic and have associated gypsum crusts, especially in the adit. All but the top 3 cm of the unit were included in the 52-cm-thick assayed sandstone sample.
23	.03	Medium-gray (N5), medium-bedded limestone. This lower assayed unit contains brachiopod fossils, pyrite micrograins, and finely macerated carbonaceous plant fragments.
≥40	.03	Medium-dark-gray (N4) shale.

mation; (b) it serves to link the various types of mineralization in the Catskill (such as in the quarry at Millview, Klemic locality 6, Sheets "coal mine," and others); (c) it is located very near the base of the Catskill; and (d) it was studied by Mahar (1978) as a copper-uranium occurrence.[1]

The Tivoli adit trends due north, is 11.6 ± 0.1 m (38.0 ± 0.3 ft) long, and in the main part is 2.5 m (8.2 ft) wide and 2.0 m (7 ft) high. The average radioactivity in the adit is 0.02 ± 0.01 "mR/hr," or 225 ± 25 cps. Carbonaceous plant fragments in the sandstone roof are barren with respect to copper and uranium. The largest fragment is 6 cm (2.4 in.) wide and 125 cm (49 in.) long, and trends approximately N35°W. Other large plant fragments trend approximately N75°W, N50°W, and N80°W.

The stratigraphy exposed at the east side of the adit entrance (the channel-sample site) is described in Table 73. The bulk of the rock exposed in the adit is gray siltstone, but the marine, pyritic limestone continues to the north end of the adit, where a large pyrite lens is also present.

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[1] Mahar (1978, p. 28) reported 2.7 to 3.5 ppm U_3O_8 and 50 to 60 ppm copper for three representative rock samples, in good agreement with the present study.

RECOMMENDATIONS FOR EXPLORATION AND RESEARCH

Although an understanding of the geometry, composition, and genesis of a metallic deposit is desirable in planning an exploration program, one must frequently begin without the benefit of a proven model. Because no proven model exists for the Picture Rocks-Sonestown region, suggestions for further study are divided into two categories: (1) those basic steps that might be of immediate, practical value in locating significant copper-uranium mineralization, regardless of the genetic aspects, and (2) those detailed steps more related to developing a genetic model, satisfying one's scientific curiosity, and perhaps leading toward more long-term practical benefits. A balanced exploration or research program would probably include some aspects of both.

RECOMMENDATIONS FOR EXPLORATION

(1) Prepare a detailed geologic map of the two quadrangles, paying particular attention to the portion of the Catskill Formation above approximately 425 m (1,400 ft) in elevation. Although some traditional aspects of mapping, such as attitude of bedding, would be essential, subdivision of the Catskill into members that have been defined in substantially different portions of the basin might be of little value. Instead of lithofacies maps at a scale of 1:24,000, what appear to be needed here are more strictly lithologic maps, at a scale of perhaps 1:10,000, that indicate individual reduced lenses and their grain size. In such a mapping system, the lower contact of a favorable member might be defined as the lowest typical occurrence of sandstones exceeding a particular grain size.

During such mapping, careful attention should be paid to the identification of the main distributary channels in the middle and upper Catskill Formation.

(2) Sample and analyze the coarser grained, reduced or altered sandstones for uranium and copper, as well as for chromium, molybdenum, selenium, and vanadium. Those showing characteristics of uranium remobilization should also be examined in thin section with special emphasis on the opaque-oxide versus leucoxene assemblage.

(3) Walk the major hollows above approximately 425 m (1,400 ft) elevation in search of float or outcrops of mineralized or altered rocks. Pronounced hollows such as Pole Bridge and the unnamed one to the northeast, and various hollows off Bully Run, Trout Run, and Rock Run are recommended in particular.

(4) Examine medium- and coarse-grained, pyritic sandstone horizons, such as the one at elevation 396 m (1,300 ft), exposed in the roadcuts on the southwest side of Trout Run, 2.5 km (1.6 mi) northwest of Muncy Valley (Figure 89). Uranium localization near former pockets of "sour" natural gas should be considered.

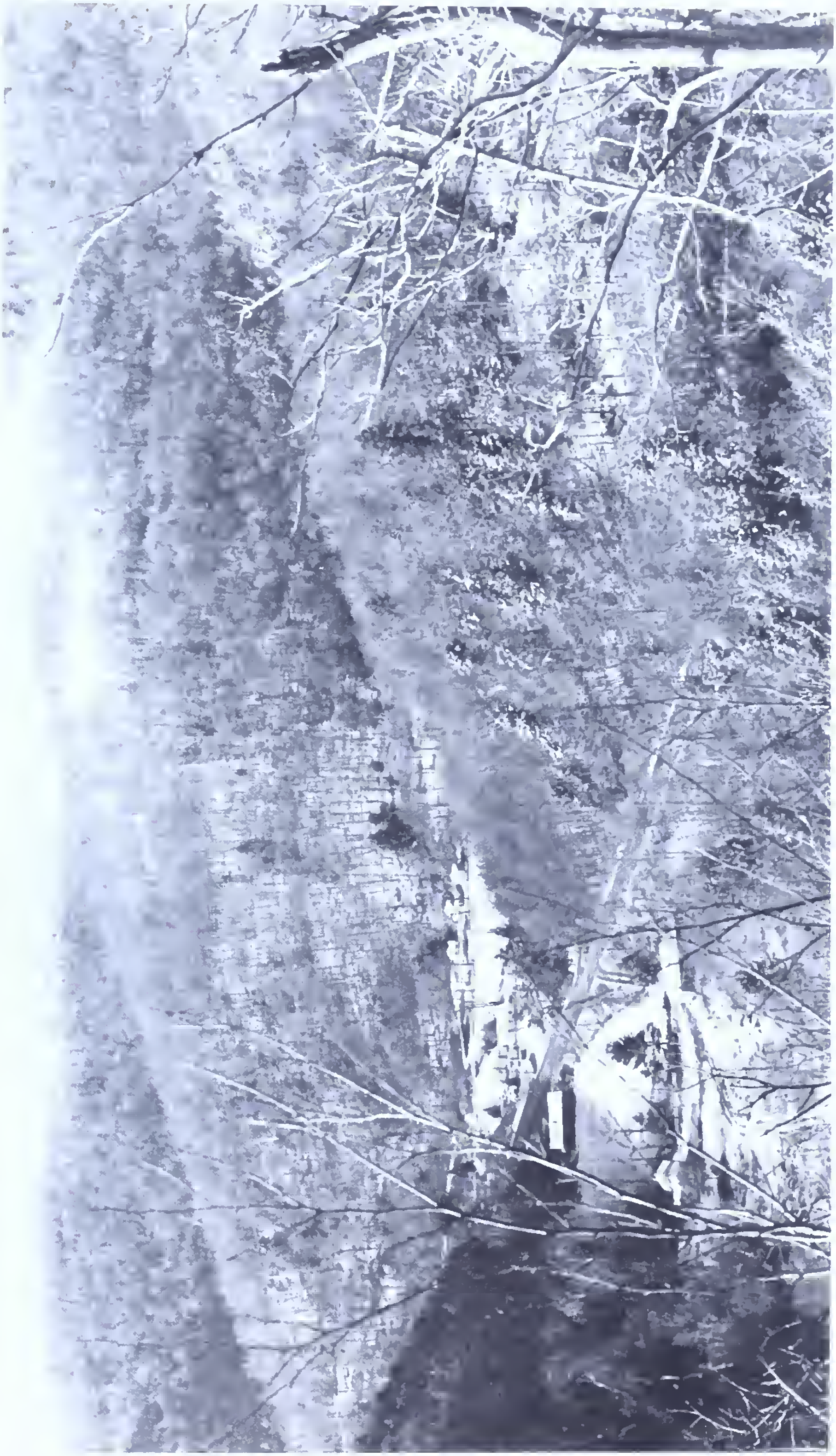

Figure 89. View from the cliff at Sheets "coal mine," looking southwest across the side valley of Trout Run. Because of the thickness of the coarser-than-average reduced horizons that have trace mineralization, the higher elevation areas should be examined for favorable units.

RECOMMENDATIONS FOR RESEARCH

(1) Map the various marine-transgression units in the lower Catskill at a scale of 1:24,000, sample the marine units, and determine the content of arsenic and other trace elements. Compare the lithologic map and trace-element data to the distributary system at higher elevations and the location of known copper-uranium occurrences.

(2) Determine the trace-element content, percent feldspar (by X-ray powder diffraction), and initial permeability of located representative samples of the normal, oxidized Catskill lithologies from base to top.

(3) Determine the reflectivity and anisotropy of coal samples from different elevations (such as from the Sheets "coal mine" and the much lower Tivoli adit or Creekside Rod and Gun Club prospects, Plate 1) and interpret the results in terms of burial conditions.

(4) Attempt to determine the degree of marine influence throughout the Catskill by examining the chlorine contents of various minerals and their fluid inclusions. Possible candidates include the rim versus cores of fossil fish remains composed of apatite-group minerals, and coarse muscovite flakes. Electron microprobe scans across coarse muscovite might also be useful in estimating the percent detrital versus authigenic or alteration overgrowth. If found to be relatively unzoned, K/Ar age estimates might prove interesting despite probable difficulties of interpretation. Analyses of both reduced and oxidized whole-rock samples for K/Ar might place some limits on the timing of the mineralization.

(5) Attempt to determine the age of uraninite through radiometric-dating techniques.

(6) Attempt to estimate marine influence via whole-rock trace-element analyses of located representative samples from a section through the Catskill. Possible indicator elements worth considering include arsenic and boron (Keith and Degens, 1959), although analytical difficulties, such as the emission spectrographic interference of iron for boron, must be considered.

(7) Attempt to determine the primary forms of vanadium and especially uranium. At the 80-m site of the Sonestown Nose uranium trench of Gill-Jordan, some vanadium occurs as probable roscoelite, but this has not been fully verified for the Sonestown Nose site or other sites. Radiograph and electron-microprobe examinations of polished thin sections are suggested for study of the freshest available uraniferous samples from various host rocks and stratigraphic positions.

(8) Determine the iron-titanium oxide mineralogy of uraniferous and possible altered samples from various host rocks and stratigraphic positions. Emphasis should be placed on coarser-than-average channels in the upper Catskill that might have been subjected to remobilization of uranium.

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APPENDICES

APPENDIX 1. LIST OF MINERAL SPECIES AND FORMULAE

Sulfides	Formulae[1]
Arsenopyrite	$FeAsS$
Bornite	Cu_5FeS_4
Chalcocite	Cu_2S
Chalcopyrite	$CuFeS_2$
Covellite	CuS
Digenite	Cu_9S_5
Djurleite	$Cu_{31}S_{16}$
Galena	PbS
Pyrite	FeS_2
Sulfosalts	
Tennantite	$(Cu,Fe)_{12}As_4S_{13}$
Tetrahedrite(?)	$(Cu,Fe)_{12}Sb_4S_{13}$
Oxides	
Cuprite	Cu_2O
Goethite as "limonite"	α-$FeO(OH)$
Uraninite	$\sim UO_2$
"Wad"(?)	Mixture of soft Mn oxides
Carbonates	
Azurite	$Cu_3(CO_3)_2(OH)_2$
Calcite	$CaCO_3$
Cerussite	$PbCO_3$
Malachite	$Cu_2(CO_3)(OH)_2$
Widenmannite	$Pb_2(UO_2)(CO_3)_3$
Sulfates	
Anglesite	$PbSO_4$
Barite	$BaSO_4$
Brochantite	$Cu_4(SO_4)(OH)_6$
Gypsum	$CaSO_4 \cdot 2H_2O$
Jarosite	$KFe_3^{3+}(SO_4)_2(OH)_6$
Langite	$Cu_4(SO_4)(OH)_6 \cdot 2H_2O$
Linarite-like mineral	$(Pb,Ca)Cu(SO_4)(OH)_2$(?)*
Plumbojarosite(?)	$PbFe_6^{3+}(SO_4)_4(OH)_{12}$
Posnjakite	$Cu_4(SO_4)(OH)_6 \cdot H_2O$
Sulfate-arsenates	
Chalcophyllite	$Cu_{18}Al_2(AsO_4)_3(SO_4)_3(OH)_{27} \cdot 33H_2O$
Beudantite(?)	$PbFe_3^{3+}(AsO_4)(SO_4)(OH)_6$
Phosphates	
Apatite group as fossil fish remains, species fluorapatite and/or carbonate-fluorapatite	$Ca_5(PO_4,CO_3)_3F$
Metatorbernite	$Cu(UO_2)_2(PO_4)_2 \cdot 8H_2O$
Torbernite(?)	$Cu(UO_2)_2(PO_4)_2 \cdot 8\text{–}12H_2O$

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[1] From Fleischer (1980), except as marked with an asterisk (*).

APPENDIX 1. *(Continued)*

Arsenates	Formulae[1]
Meta-uranospinite–metazeunerite solid solution(?)	$(Ca,Cu)(UO_2)(AsO_4)_2 \cdot 8H_2O$
Metazeunerite	$Cu(UO_2)_2(AsO_4)_2 \cdot 8H_2O$
Olivenite	$Cu_2AsO_4(OH)$
Tyrolite	$CaCu_5(AsO_4)_2(CO_3)(OH)_4 \cdot 6H_2O$
Zeunerite	$Cu(UO_2)_2(AsO_4)_2 \cdot 10\text{–}16H_2O$
Vanadates	Formulae[1]
Francevillite	$(Ba,Pb)(UO_2)_2(VO_4)_2 \cdot 5H_2O$
Metatyuyamunite	$Ca(UO_2)_2(VO_4)_2 \cdot 3\text{–}5H_2O$
Tyuyamunite	$Ca(UO_2)_2(VO_4)_2 \cdot 5\text{–}8H_2O$
Silicates	
Beta-uranophane	$Ca(UO_2)_2Si_2O_7 \cdot 6H_2O$
Chrysocolla	$(Cu,Al)_2H_2Si_2O_5(OH)_4 \cdot nH_2O$
Cuprosklodowskite	$Cu(UO_2)_2Si_2O_6(OH)_2 \cdot 5H_2O$
Kasolite	$Pb(UO_2)SiO_4 \cdot H_2O$
Opal	$SiO_2 \cdot nH_2O$
Quartz	SiO_2
Roscoelite(?)	$K(V,Al,Mg)_2AlSi_3O_{10}(OH)$
Uranophane	$Ca(UO_2)_2Si_2O_7 \cdot 6H_2O$
Molybdates	
Wulfenite	$PbMoO_4$

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[1] From Fleischer (1980).

APPENDIX 2. TABULATION OF VERY SMALL COPPER-URANIUM OCCURRENCES IN THE PICTURE ROCKS AND SONESTOWN QUADRANGLES

Name	Latitude	Longitude	Comments
Edler Drive	41°18′08″	76°38′02″	Up to 600 ppm eU on gray sandstone in small outcrop on north side of access road.
Fort Sumpter area	41°18′53″	76°41′44″	Malachite on one large plant fossil in gray sandstone yields $R_{max.}$ of 300 cps.
Iron bridge overlook	~41°18′08″	~76°40′57″	Trace malachite and "chalcocite" in calcareous breccia about 25 m (80 ft) below marine zone.
Lewis Flick	41°17′04″	76°33′11″	Visible malachite in 10- by 75-cm (4- by 30-in.) lens in red, crossbedded siltstone. $R_{max.} = 0.12$ "mR/hr."
McCauley 24 fishpond overlook	~41°19′01″	~76°41′30″	Mahar (1978) has an unexplained "X" in this area. One piece of calcareous breccia float containing trace malachite was found.
Myers Sawmill Road	41°18′57″	76°35′23″	Radioactivity is slightly high below overhang in oxidized rocks near the top of a large outcrop.
No. 22	~41°21′38″	~76°35′38″	Reported by Roe and Martin (1982) to have a radioactivity of four times background over an area of 0.15 by 0.6 m (0.5 by 2 ft). Not examined.
No. 23	~41°20′59″	~76°33′18″	Reported by Roe and Martin (1982) to contain up to 93 ppm U_3O_8 and 1.7 percent copper. Not examined.
Old U.S. 220 culvert	41°22′03″	76°32′14″	$R_{max.} \cong 0.15$ "mR/hr." Malachite and "chalcocite" in calcareous breccia and greenish-gray slab near base of ~3 m (10 ft) thick reduced zone. Yields 230 ppm eU at best spot, but drops off in <1 m (3 ft) laterally. Length of discontinuous outcrop with ≥ 200 cps is 12 m (40 ft).
Pole Bridge Hollow area	41°20′26″	76°33′34″	Trace malachite in calcareous breccia "plum pudding" at base of 9.3-m- (30-ft-) thick reduced zone. More planar bedded (small flagstone quarry) and finer grained than to east.
Rusty Logjam	41°18′07″	76°41′02″	$R_{max.} = 0.06$ "mR/hr" on gray siltstone ~3 m (10 ft) above floor of back of trench that trends N50°W. Reduced sandstone containing large carbonaceous fossils can be traced over 30 m (100 ft) to southeast.

APPENDIX 3. ANALYSES OF CHANNEL SAMPLES

Table 74. *Location and Description Data for Analyzed Samples*

Sample number and cluster	Name	Channel-sample description[1]	Approximate elevation (ft)	Latitude Longitude
MHK 727 Beaver Lake	Copper Hollow 8 prospect	51 cm (20 in.); 0.08 "mR/hr"; siltstone and sandstone	1,020	41°17′20″ 76°36′11″
MHK 728 McCauley 22	McCauley prospect 22, 10.2-m site	20 cm (8 in.); 0.8 "mR/hr"; carbonaceous sandstone	1,070	41°18′10″ 76°39′24″
MHK 729 Beaver Lake	Copper Hollow 6 prospect	47 cm (18 in.); 0.07 "mR/hr"; medium-grained sandstone and calcareous breccia	1,020	41°17′20″ 76°36′09″
MHK 730 Old/New U.S. 220	New U.S. Route 220 uranium-copper occurrences, southwest site	26 cm (10 in.); 0.13 "mR/hr"; micaceous siltstone and sandstone	1,480	~41°21′56″ ~76°32′02″
MHK 731 Miscellaneous	McCauley prospect 17	0.1 "mR/hr"; composite of chips from dump	1,190	41°16′34″ 76°34′34″
MHK 732 North Mountain	Jordan North Mountain uranium prospect 2	22 cm (9 in.); 0.1 "mR/hr"; sandstone	1,470	41°18′21″ 76°34′04″
MHK 733 Old/New U.S. 220	New U.S. Route 220 uranium-copper occurrences, northeast site	18 cm (7 in.); 0.5 "mR/hr"; carbonaceous and "maroon" sandstone	1,480	~41°21′56″ ~76°32′02″
MHK 734 McCauley 22	McCauley prospect 22, northwest side of southeast adit	36 cm (14 in.); 0.5 "mR/hr"; carbonaceous sandstone. Collected by R. B. Koeberle.	1,070	41°18′10″ 76°39′24″
MHK 735 McCauley 22	McCauley prospect 22, northwest side of southeast adit	36 cm (14 in.); 0.5 "mR/hr"; carbonaceous sandstone. Same zone as MHK 734 but collected by R. C. Smith.	1,070	41°18′10″ 76°39′24″
MHK 736 Beaver Lake	McCauley prospect 19 (Klemic locality 10), northeast adit	0.03 "mR/hr"; composite of calcareous breccia and sandstone chips from dump	980	41°17′21″ 76°35′36″
MHK 737 Muncy Valley	Jordan borrow pit	2 cm (0.8 in.); 0.08 "mR/hr"; micaceous and carbonaceous sandstone	1,140	41°18′40″ 76°34′38″
MHK 738	Klemic locality 8 (Beaver Lake	28 cm (11 in.); 0.07 "mR/hr"; shale and silt-	910	41°18′11″

MHK 740 Sonestown Nose A	McCauley prospect 29	45 cm (18 in.); 0.03 "mR/hr"; sandstone from bed containing mineralized fossil plant limb	1,040	41°21′26″ 76°33′01″
MHK 741 Rock Run	McCauley prospect 28-1/2 of Mahar	77 cm (30 in.); 0.03 "mR/hr"; siltstone and shale. Mineralization continues at bottom.	950	41°20′41″ 76°37′32″
MHK 742 Sonestown Nose B	Sonestown Nose uranium trench of Gill-Jordan, 22.5-m site (reference point is at southeast end of trench)	27 cm (11 in.); 0.3 "mR/hr"; fine-grained gray and "maroon" sandstone and calcareous breccia	1,230	41°21′34″ 76°32′51″
MHK 743 Fox Run Valley	McCauley prospect 24	42 cm (17 in.); 0.03 "mR/hr"; calcareous breccia	930	41°19′11″ 76°41′24″
MHK 744 Fox Run Valley	McCauley prospect 24	72 cm (28 in.); 0.1 "mR/hr"; sandstone above MHK 743	930	41°19′11″ 76°41′24″
MHK 745 Rock Run	Rock Run uranium occurrence	16 cm (6 in.); 0.35 "mR/hr"; micaceous sandstone	870	41°20′19″ 76°37′58″
MHK 746 Sonestown Nose B	Sonestown Nose uranium trench of Gill-Jordan, 68.7-m site (reference point is at southeast end of trench)	60 cm (24 in.); 0.15 "mR/hr"; micaceous sandstone	1,230	41°21′34″ 76°32′51″
MHK 747 Sonestown Nose B	Sonestown Nose uranium trench of Gill-Jordan, 68.7-m site (reference point is at southeast end of trench)	27 cm (11 in.); 0.4 "mR/hr"; calcareous breccia above MHK 746	1,230	41°21′34″ 76°32′51″
MHK 748 Rock Run	Rock Run Church copper prospect	20 cm (8 in.); 0.1 "mR/hr"; carbonaceous sandstone	910	41°20′11″ 76°38′26″
MHK 749 North Mountain	Jordan North Mountain uranium prospect 1	13 cm (5 in.); 0.05 "mR/hr"; medium-grained sandstone	1,450	41°18′22″ 76°34′08″
MHK 750 Fox Run Valley	Tivoli Overlook copper-uranium occurrence 1	48 cm (19 in.); 0.05 "mR/hr"; fine-grained sandstone	990	41°18′11″ 76°41′02″
MHK 751 Fox Run Valley	Tivoli Overlook copper-uranium occurrence 2	15 cm (6 in.); 0.35 "mR/hr"; carbonaceous and calcareous shale and siltstone	980	41°18′14″ 76°41′03″

Table 74. *(Continued)*

Sample number and cluster	Name	Channel-sample description[1]	Approximate elevation (ft)	Latitude Longitude
MHK 752 Fox Run Valley	McCauley prospect 24-1/2 of Mahar (Birch Still Road reduced zone)	18 cm (7 in.); 0.03 ''mR/hr''; medium-grained sandstone and minor calcareous breccia	900	41°19′16″ 76°40′28″
MHK 753 Strawbridge	Strawbridge copper prospect 2	~0.1 ''mR/hr''; composite of sandstone chips from dump	980	41°18′44″ 76°37′30″
MHK 754 Strawbridge	Strawbridge uranium-copper lens	50 cm (20 in.); 0.12 ''mR/hr''; siltstone and calcareous breccia	1,020	41°18′40″ 76°37′29″
MHK 755 Strawbridge	Strawbridge copper prospect 1	33 cm (13 in.); 2.0 ''mR/hr''; carbonaceous sandstone	980	41°18′44″ 76°37′31″
MHK 756 Strawbridge	Strawbridge copper prospect 1	21 cm (8 in.); 1.5 ''mR/hr''; calcareous breccia between MHK 755 and MHK 757	980	41°18′44″ 76°37′31″
MHK 757 Strawbridge	Strawbridge copper prospect 1	125 cm (49 in.); 0.09 ''mR/hr''; sandstone below MHK 756	980	41°18′44″ 76°37′31″
MHK 758 Rock Run	McCauley prospect 28	75 cm (30 in.); 0.1 ''mR/hr''; carbonaceous sandstone	870	41°20′20″ 76°37′57″
MHK 759 Rock Run	McCauley prospect 28	15 cm (6 in.); 0.06 ''mR/hr''; calcareous breccia between MHK 758 and MHK 760	870	41°20′20″ 76°37′57″
MHK 760 Rock Run	McCauley prospect 28	25 cm (10 in.); 0.07 ''mR/hr''; greenish-gray shale below MHK 759	870	41°20′20″ 76°37′57″
MHK 761 Muncy Valley	Klemic locality 12, southwest site	73±2 cm (29±0.8 in.); 0.05 ''mR/hr''; calcareous breccia	1,070	41°19′13″ 76°35′04″
MHK 762 Muncy Valley	McCauley prospect 26	64 cm (25 in.); 0.05 ''mR/hr''; sandstone	1,160	41°19′50″ 76°37′01″
MHK 763 Muncy Valley	McCauley prospect 26	20 cm (8 in.); 0.07 ''mR/hr''; calcareous breccia below MHK 762	1,160	41°19′50″ 76°37′01″
MHK 764 Beaver Lake	McCauley prospect 19 (Klemic locality 10), southwest adit	0.03 ''mR/hr''; composite of calcareous breccia and sandstone chips from dump	980	41°17′21″ 76°35′37″
MHK 765 Beaver Lake	Copper Hollow 1 uranium-copper prospect	48 cm (19 in.); 0.09 ''mR/hr''; sandstone, siltstone, and calcareous breccia	1,010	41°17′20″ 76°36′04″
MHK 766 Muncy Valley	Copper Hollow 5A prospect	56 cm (22 in.); 0.04 ''mR/hr''; calcareous brec-	1,020	41°17′20″

Muncy Valley		‘‘maroon’’ blotches		76°35′02″
MHK 768 Muncy Valley	Klemic locality 12, northeast site	19 cm (7.5 in.); 0.07 ‘‘mR/hr’’; sandstone having no ‘‘maroon’’ blotches; from same bed as MHK 767	1,070	41°19′13″ 76°35′02″
MHK 769 Muncy Valley	Klemic locality 12, northeast site	51 cm (20 in.); 0.035 ‘‘mR/hr’’; calcareous breccia above MHK 767 and MHK 768	1,070	41°19′13″ 76°35′02″
MHK 770 Beaver Lake	McCauley prospect 19 (Klemic locality 10), upper limonitic uranium zone occurrence	31 cm (12 in.); 0.11 ‘‘mR/hr’’; micaceous sandstone	980	41°17′20″ 76°35′38″
MHK 771 Sonestown Nose B	Sonestown Nose Northwest uranium-copper occurrence	21 cm (8 in.); 0.07 ‘‘mR/hr’’; calcareous sandstone	1,230	41°21′38″ 76°33′02″
MHK 772 Sonestown Nose C	Sonestown Nose Reduced Cap copper-uranium zone, 11.7-m site (reference point is at northwest end of outcrop)	35 cm (14 in.); 0.1 ‘‘mR/hr’’; ‘‘maroon’’ and gray, medium-grained sandstone	1,380	41°21′28″ 76°32′50″
MHK 773 Sonestown Nose C	Sonestown Nose Reduced Cap copper-uranium zone, 56.7-m site (reference point is at northwest end of outcrop)	17 cm (7 in.); 0.07 ‘‘mR/hr’’; ‘‘maroon’’ sandstone	1,380	41°21′28″ 76°32′50″
MHK 774 Sonestown Nose C	Sonestown Nose Reduced Cap copper-uranium zone, 56.7-m site (reference point is at northwest end of outcrop)	30 cm (12 in.); 0.1 ‘‘mR/hr’’; copper-stained ‘‘maroon’’ sandstone below MHK 773	1,380	41°21′28″ 76°32′50″
MHK 775 Beaver Lake	McCauley prospect 21, main underhang	26 cm (10 in.); 0.2 ‘‘mR/hr’’; sandstone and calcareous breccia	1,040	41°17′39″ 76°36′21″
MHK 776 Beaver Lake	McCauley prospect 21, 34-m site	15 cm (6 in.); 1.5 ‘‘mR/hr’’; ‘‘maroon’’ sandstone	1,040	41°17′39″ 76°36′21″
MHK 777 Sonestown Nose B	Middle Catskill Reduced Zone uranium-copper occurrence	33 cm (13 in.); 0.07 ‘‘mR/hr’’; calcareous breccia	1,170	41°20′41″ 76°33′02″
MHK 778 Sonestown Nose B	Middle Catskill Reduced Zone uranium-copper occurrence	5 cm (2 in.); 0.04 ‘‘mR/hr’’; medium-grained sandstone with reddish-brown weathering rind above MHK 777	1,170	41°20′41″ 76°33′02″

Table 74. *(Continued)*

Sample number and cluster	Name	Channel-sample description[1]	Approximate elevation (ft)	Latitude Longitude
MHK 779 Beaver Lake	Jordan Sawmill adits, southwest copper adit	95 cm (37 in.); 0.07 "mR/hr"; siltstone and shale	980	41°18′40″ 76°35′06″
MHK 780 Old/New U.S. 220	Bench Mark 359 uranium-copper-lead occurrence, 1.6-m west site	35 cm (14 in.); 0.3 "mR/hr"; medium-grained, gray and "maroon" sandstone	1,460	41°22′08″ 76°32′08″
MHK 781 Old/New U.S. 220	Bench Mark 359 uranium-copper-lead occurrence, 1.6-m west site	60 cm (24 in.); 0.1 "mR/hr"; coarse-grained gray and "maroon" sandstone below MHK 780	1,460	41°22′08″ 76°32′08″
MHK 782 Old/New U.S. 220	Bench Mark 359 uranium-copper-lead occurrence, 11-m northeast site	9 cm (3.5 in.); 0.8 "mR/hr"; "maroon" and carbonaceous sandstone	1,460	41°22′08″ 76°32′08″
MHK 783 Fox Run Valley	Old Copper open pit	~0.03 "mR/hr"; composite of all types of reduced chips from dump and vegetation-scar area	1,090	41°18′54″ 76°41′01″
MHK 784 Strawbridge	Strawbridge Northwest uranium-copper lens	55 cm (22 in.); 0.12 "mR/hr"; sandstone	970	41°18′45″ 76°37′32″
MHK 785 Beaver Lake	Hamilton-Jordan copper-uranium prospect	87 cm (34 in.); 0.2 "mR/hr"; shale and sandstone	1,100	41°17′10″ 76°36′21″
MHK 786 Fox Run Valley	McCauley prospect 23	110 cm (43 in.); 0.5 "mR/hr"; calcareous sandstone	990	41°18′34″ 76°40′46″
MHK 787 Fox Run Valley	Old Farm uranium-copper occurrence	123 cm (48 in.); 0.3 "mR/hr"; sandstone	980	41°18′32″ 76°41′34″
MHK 788 Miscellaneous	Tivoli adit	52 cm (20 in.); 0.02 "mR/hr"; pyritic, marine sandstone containing carbonaceous plant fragments	800	41°17′56″ 76°41′38″
MHK 789 Miscellaneous	Tivoli adit	23 cm (9 in.); 0.03 "mR/hr"; pyritic limestone containing brachiopods and carbonaceous plant	800	41°17′56″ 76°41′38″

MHK 790 Fox Run Valley	Lukin uranium-copper prospect	25 cm (10 in.); 0.12 "mR/hr"; carbonaceous sandstone	[illegible]	[illegible] 76°39′52″
MHK 791 Miscellaneous	Hill Family Reduced Zone copper-uranium occurrences, occurrence A	91 cm (36 in.); 0.15 "mR/hr"; calcareous sandstone. Mineralization continues at bottom.	1,180	41°18′08″ 76°37′22″
MHK 792 Beaver Lake	McCauley prospect 18 (Klemic locality 11; Avery Brothers uranium adit)	Composite of siltstone and shale from dump	980	41°17′07″ 76°36′00″
MHK 793 McCauley 22	Edler Lake uranium-copper occurrence	65 cm (26 in.); 0.2 "mR/hr"; siltstone and sandstone	1,030	41°18′20″ 76°38′50″
MHK 794 Miscellaneous	Allegheny Ridge copper-uranium occurrence	45 cm (18 in.); 0.05 "mR/hr"; micaceous, medium-grained sandstone	1,720	41°21′14″ 76°39′04″
PRS-1 Fox Run Valley	Fort Sumpter uranium prospect	55 cm (22 in.); 0.2 "mR/hr"; calcareous sandstone and calcareous breccia	1,050	41°18′52″ 76°41′51″
PRS-2 Miscellaneous	Marquardt copper occurrence	8 cm (3 in.); medium-grained sandstone	1,590	41°21′14″ 76°36′21″
PRS-3 Front	Sheets "coal mine" uranium-lead occurrence	34 cm (13 in.); 0.1 "mR/hr"; sandstone with minor "maroon" coloration below PRS-4	1,360	41°21′28″ 76°35′03″
PRS-4 Front	Sheets "coal mine" uranium-lead occurrence	85 cm (33 in.); 0.06 "mR/hr"; pyritic shale and siltstone with coal seams, above PRS-3	1,360	41°21′28″ 76°35′03″
PRS-5 Front	Upper Catskill Reduced Zone copper occurrence	22 cm (9 in.); 0.04 "mR/hr"; calcareous breccia	1,310	41°21′31″ 76°35′09″
PRS-6 Muncy Valley	Shultz copper adit	47 cm (18 in.); 0.07 "mR/hr"; shale and siltstone above PRS-7	1,120	41°20′44″ 76°34′02″
PRS-7 Muncy Valley	Shultz copper adit	26 cm (10 in.); 0.15 "mR/hr"; sandstone with minor "maroon" coloration at base, below PRS-6	1,120	41°20′44″ 76°34′02″
PRS-8 Miscellaneous	Marquardt uranium occurrence	26 cm (10 in.); 0.05 "mR/hr"; sandstone containing carbonaceous plant fragments	1,580	41°21′14″ 76°36′20″
PRS-9 Sonestown Nose A	Mosey Glen uranium-copper occurrence	31 cm (12 in.); 0.2 "mR/hr"; siltstone and shale	1,100	41°21′45″ 76°32′56″

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[1] All lithologies are gray, i.e., reduced, unless otherwise noted. See stratigraphic descriptions in individual sections in text for details.

Table 75. *Geochemical Analyses for Uranium, Copper, Arsenic, and Lead*

The sample descriptions are provided in the preceding table. Most are true channel samples. Quantities are in parts per million. Multiple values represent replicate analyses of the same sample pulps.

	MHK 727	MHK 728	MHK 729	MHK 730	MHK 731	MHK 732	MHK 733	MHK 734	MHK 735
U_3O_8	27	1,390	12	397	340	57	978	260	130
Cu	4,600	13,500	5,350	7,000	4,950	270	4,100	13,500	12,500
As	25	2,450	100	30	215; 190; 120	30	20	680	460
Pb	10	1,300	30	600	200	220	35	1,000	900
	MHK 736	MHK 737	MHK 738	MHK 739	MHK 740	MHK 741	MHK 742	MHK 743	MHK 744
U_3O_8	62	48	5	11	10	2	318 181	8	17
Cu	4,150	4,850	5,500	280	145	1,050	16,500; 16,500	4,750	9,500
As	165	115	45	160	25	5	470; 460; 590	25	70
Pb	30	45	580	2,800	15	15	800; 890	650	3,200
	MHK 745	MHK 746	MHK 747	MHK 748	MHK 749	MHK 750	MHK 751	MHK 752	MHK 753
U_3O_8	248	29	400; 222	43	3	8	396	3	78
Cu	290	1,450	6,500; 6,400	30,500	2,250	2,350	31,000	440	2,450
As	90	40	860; 900; 920	85	10	55	1,050	10	215
Pb	3,800	340	4,200	80	5	25	210	10	1,100
	MHK 754	MHK 755	MHK 756	MHK 757	MHK 758	MHK 759	MHK 760	MHK 761	MHK 762

Pb	190	1,600	2,300	85	4,200	100	80	20	15
	MHK 763	MHK 764	MHK 765	MHK 766	MHK 767	MHK 768	MHK 769	MHK 770	MHK 771
U_3O_8	25	40	128	11	254	34	6	509	32
Cu	5,400	1,150	11,500	3,400	2,200	550	200	2,600	1,100
As	200	225	330	80	100	10	5	760	35
Pb	290	290	60	50	45	10	25	335	85
	MHK 772	MHK 773	MHK 774	MHK 775	MHK 776	MHK 777	MHK 778	MHK 779	MHK 780
U_3O_8	39	24	51	300	3,200	56	9	39	339
Cu	4,200	5,000	17,000	17,000	4,600	305	350	3,000	800
As	15; 10	40	155	70	1,200	55	10	5	175
Pb	30	10; 10; <5	15	35	235	110	10	20	9,800
	MHK 781	MHK 782	MHK 783	MHK 784	MHK 785	MHK 786	MHK 787	MHK 788	MHK 789
U_3O_8	68	630; 743	6	50	187	94; 83	143	3	2
Cu	470	4,400	700	435	1,100	3,550	3,400	25	20
As	10	200	10	145	65	140	275	180	50
Pb	800	555	1,000	2,000	35	210	1,600	60	50
	MHK 790	MHK 791	MHK 792	MHK 793	MHK 794				
U_3O_8	67	70	700	100	10				
Cu	26,000	9,000	52,000	1,000	550				
As	40	155	640	120	10				
Pb	30	2,700	675	575	30				
	PRS-1	PRS-2	PRS-3	PRS-4	PRS-5	PRS-6	PRS-7	PRS-8	PRS-9
U_3O_8	55	4	67	11	8	10	110	14	625
Cu	3,400	900	140	45	2,200	1,000	3,800	265	3,200
As	80	<5	5	70	25	25	70	250	520
Pb	85	5	835	1,600	30	15	10	7,800	250

Table 76. *Semiquantitative Trace-Element Analyses*

Channel samples were collected from the Catskill Formation by personnel of the Pennsylvania Geological Survey and the William Penn Memorial Museum. Splits of the samples were analyzed through the courtesy of the Bendix Field Engineering Corporation (in conjunction with their Williamsport 1- by 2-degree quadrangle project). The analyses were done by TSL Laboratories, Limited, using an inductively coupled argon-plasma emission spectrographic procedure. Preferred, quantitative estimates for arsenic, copper, and lead, and selected verifications of silver, molybdenum, selenium, and vanadium are presented in Tables 75 and 77. The following data are in parts per million.

	MHK 727	MHK 728	MHK 729	MHK 730	MHK 731	MHK 732	MHK 733	MHK 734	MHK 735	MHK 736
Ag	10	62	7	19	19	2	16	28	27	6
Al	96,500	>100,000	>100,000	>100,000	>100,000	82,000	79,000	72,400	73,600	46,600
B	145	130	99	110	96	125	140	105	105	60
Ba	485	375	590	2,360	320	490	3,150	380	375	450
Be	4	5	4	4	3	4	6	4	4	2
Ca	5,610	9,780	39,800	9,045	6,520	2,240	3,095	1,460	1,290	39,900
Co	25	24	24	33	23	32	38	35	31	18
Cr	86	84	70	82	66	97	90	97	98	59
Cu	4,410	13,200	4,925	7,350	4,980	340	4,060	13,900	13,700	4,000
Fe	30,300	33,600	29,800	34,500	32,400	34,100	44,600	26,000	37,100	20,900
La	42	33	45	43	36	47	56	33	30	52
Li	65	115	50	100	65	65	80	135	135	45
Mn	770	850	3,880	1,470	1,400	915	990	940	805	5,110
Mo	14	38	32	30	25	16	17	16	15	11
Na	9,400	8,300	10,600	9,400	8.800	9,900	9,400	9,900	11,900	8,300
Nb	3	3	2	3	2	3	6	3	3	2
Ni	51	49	40	54	45	49	50	47	50	30
Pb	65	1,440	175	665	335	310	120	1,275	1,000	83
Sb	<1	177	127	107	67	22	30	38	26	15
Sc	12	11	11	13	9	12	12	9	9	5
Sr	<100	<100	100	<100	<100	<100	<100	<100	<100	160
Ti	3,070	2,510	2,020	3,260	2,460	3,790	4,860	3,740	3,335	2,390
V	120	150	92	220	79	315	810	165	160	67
Y	18	29	21	17	33	17	61	25	22	47
Zr	86	92	65	84	67	100	110	110	100	47

	MHK 737	MHK 738	MHK 739	MHK 740	MHK 741	MHK 742	MHK 743	MHK 744	MHK 745	MHK 746
Ag	10	13	2	<1	4	26	9	12	46	4
Al	>100,000	>100,000	56,000	>100,000	>100,000	71,100	48,300	59,900	>100,000	56,800
B	110	160	99	99	180	110	67	82	150	160
Ba	715	540	340	490	725	1,290	570	405	375	315
Be	5	7	3	3	6	6	3	2	6	4
Ca	4,870	18,500	1,740	8,360	1,560	3,500	39,900	3,670	5,420	20,400
Co	29	58	31	25	43	69	20	23	47	32
Cr	97	130	84	80	155	88	74	80	105	90
Cu	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Fe	34,300	41,000	31,600	35,400	52,200	30,700	20,700	21,800	48,400	63,700

Fe	34,300	41,000	31,600	35,400	52,200	30,700	20,700	21,800	48,400	63,700
La	21	34	50	63	29	78	55	49	31	51
Li	160	100	95	55	90	175	60	205	155	75
Mn	960	1,860	1,290	1,955	950	1,400	4,870	1,020	890	2,060
Mo	22	26	29	20	22	14	10	31	66	16
Na	13,800	6,600	9,900	13,000	6,600	16,600	8,300	8,300	11,900	16,600
Nb	4	5	2	2	5	7	2	2	4	3
Ni	46	74	43	41	76	42	37	34	53	41
Pb	160	710	3,280	135	105	950	725	3,810	4,430	400
Sb	72	112	12	42	47	29	13	16	157	14
Sc	8	15	7	10	14	11	5	7	11	8
Sr	<100	<100	<100	<100	<100	<100	150	<100	<100	<100
Ti	3,050	3,540	2,725	3,920	3,960	6,180	2,670	2,870	3,360	3,440
V	320	180	71	89	170	1,080	78	66	130	365
Y	21	15	14	20	10	170	28	17	16	23
Zr	66	89	105	94	90	160	64	80	93	78

	MHK 747	MHK 748	MHK 749	MHK 750	MHK 751	MHK 752	MHK 753	MHK 754	MHK 755	MHK 756
Ag	44	84	1	<1	31	1	7	19	46	5
Al	49,200	76,800	>100,000	>100,000	>100,000	50,500	51,700	53,500	49,200	56,200
B	72	120	86	110	165	115	130	100	115	105
Ba	490	910	420	540	1,610	440	275	315	330	305
Be	3	5	2	3	6	2	3	3	3	3
Ca	39,900	2,460	7,220	8,260	16,300	17,100	5,080	39,500	1,400	39,600
Co	29	31	18	25	47	23	27	20	24	23
Cr	62	87	52	71	110	70	77	75	68	63
Cu	16,100	21,900	2,550	2,740	21,900	560	2,295	6,520	14,600	6,870
Fe	23,100	30,100	23,400	30,200	34,700	26,300	29,500	25,800	24,500	22,100
La	47	48	25	24	69	54	41	33	34	56
Li	65	125	120	115	115	65	85	65	95	75
Mn	4,550	2,930	735	1,160	2,230	3,140	980	3,060	865	3,050
Mo	49	15	19	24	39	9	15	9	16	20
Na	7,400	7,400	11,900	9,900	10,600	9,400	8,800	7,800	9,400	8,300
Nb	4	4	2	2	5	2	2	3	2	2
Ni	30	51	30	42	59	38	42	40	39	34
Pb	4,025	210	115	135	360	49	1,340	220	1,580	1,950
Sb	41	58	57	67	112	<1	6	<1	11	<1
Sc	6	12	10	9	18	7	7	8	7	9
Sr	100	<100	<100	<100	<100	<100	<100	<100	<100	<100
Ti	3,025	3,510	2,140	2,585	4,240	4,775	3,820	2,440	2,370	2,775
V	875	275	190	110	320	67	125	310	99	94
Y	125	69	19	11	69	24	17	26	29	32
Zr	56	110	49	72	105	110	94	56	68	75

Table 76. *(Continued)*

	MHK 757	MHK 758	MHK 759	MHK 760	MHK 761	MHK 762	MHK 763	MHK 764	MHK 765	MHK 766
Ag	<1	1	4	5	2	2	10	.5	10	3
Al	44,800	58,400	22,700	>100,000	60,000	70,000	40,000	70,000	40,000	20,000
B	175	190	82	165	15	20	15	15	15	15
Ba	400	340	215	570	500	300	150	200	100	70
Be	2	3	2	6	1	1	1	1	1	1
Ca	19,800	3,170	39,900?	2,350	20,000	7,000	70,000	70,000	7,000	50,000
Co	18	24	12	35	5	15	15	15	15	5
Cr	55	65	37	105	30	50	50	50	30	10
Cu	1,480	420	2,810	1,575	500	500	3,000	500	3,000	1,000
Fe	22,200	32,800	11,600	35,100	10,000	15,000	10,000	15,000	10,000	3,000
La	40	27	40	25	100	70	50	50	20	50
Li	55	105	40	75	<100	<100	<100	<100	<100	<100
Mn	1,500	810	4,990	660	3,000	700	3,000	3,000	1,500	3,000
Mo	9	75	8	16	<5	<5	15	<5	<5	<5
Na	9,400	11,200	4,650	4,850	7,000	10,000	10,000	10,000	10,000	10,000
Nb	2	2	1	4	<10	<10	<10	<10	<10	<10
Ni	33	32	24	61	20	30	30	30	20	10
Pb	130	3,710	125	150	<10	50	150	300	70	10
Sb	<1	4	2	32	<100	<100	<100	<100	<100	<100
Sc	6	9	3	16	10	5	5	10	5	<5
Sr	<100	<100	200	<100	100	<100	100	100	<100	<100
Ti	2,405	2,350	1,200	2,740	2,000	3,000	1,500	3,000	2,000	1,500
V	64	94	57	155	50	70	70	50	50	30
Y	17	12	21	14	50	10	30	20	20	10
Zr	78	80	25	69	200	200	100	150	100	70

	MHK 767	MHK 768	MHK 769	MHK 770	MHK 771	MHK 772	MHK 773	MHK 774	MHK 775	MHK 776
Ag	3	<.5	<.5	7	.5	7	7	15	10	7
Al	70,000	60,000	50,000	50,000	50,000	40,000	50,000	40,000	70,000	60,000
B	15	20	15	15	15	15	10	10	30	30
Ba	200	150	300	500	300	300	300	200	300	300
Be	2	2	1	2	1	1	1	1	3	3
Ca	10,000	7,000	50,000	1,500	10,000	3,000	2,000	5,000	20,000	1,000
Co	15	15	5	15	15	5	15	10	10	20
Cr	50	50	20	30	30	20	30	20	30	50
Cu	1,500	200	100	1,500	300	5,000	5,000	7,000	7,000	2,000
Fe	15,000	15,000	7,000	15,000	15,000	10,000	20,000	15,000	10,000	20,000

La	50	50	50	50	50	20	50	20	70	70
Li	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100
Mn	700	1,000	5,000	200	1,500	700	500	1,500	1,500	200
Mo	<5	<5	<5	70	<5	<5	<5	<5	<5	<5
Na	7,000	10,000	10,000	7,000	10,000	10,000	10,000	10,000	10,000	10,000
Nb	10	10	<10	<10	<10	<10	<10	<10	<10	20
Ni	30	30	10	30	20	15	20	15	30	30
Pb	70	10	<10	200	150	50	10	10	30	300
Sb	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100
Sc	10	10	5	10	5	<5	5	5	15	15
Sr	<100	<100	<100	<100	<100	<100	<100	<100	100	<100
Ti	5,000	5,000	2,000	5,000	3,000	3,000	2,000	2,000	7,000	10,000
V	70	70	50	70	50	70	70	100	70	300
Y	70	30	30	100	20	20	10	30	70	300
Zr	300	300	100	200	150	100	70	70	300	700

	MHK 777	MHK 778	MHK 779	MHK 780	MHK 781	MHK 782	MHK 783	MHK 784	MHK 785	MHK 786
Ag	<.5	<.5	7	7	7	15	2	3	5	20
Al	70,000	60,000	70,000	50,000	70,000	70,000	70,000	70,000	70,000	70,000
B	10	15	15	10	15	10	20	20	30	20
Ba	300	300	500	200	300	300	200	200	300	150
Be	1	1	2	1	2	1	1	2	3	2
Ca	70,000	2,000	1,000	1,000	20,000	2,000	1,000	7,000	1,000	15,000
Co	15	20	20	15	30	50	10	30	20	20
Cr	70	70	100	30	50	50	100	150	150	100
Cu	300	200	2,000	500	500	2,000	300	500	1,500	2,000
Fe	15,000	15,000	20,000	15,000	15,000	20,000	15,000	20,000	20,000	15,000
La	100	50	20	20	50	50	50	50	50	50
Li	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100
Mn	2,000	500	300	1,000	3,000	500	500	1,000	300	3,000
Mo	<5	<5	<5	5	<5	20	20	15	5	<5
Na	10,000	10,000	10,000	10,000	10,000	10,000	10,000	15,000	10,000	10,000
Nb	<10	<10	<10	<10	<10	<10	10	<10	10	<10
Ni	30	30	70	20	30	30	30	50	50	30
Pb	150	20	30	7,000	1,000	300	500	2,000	150	150
Sb	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100
Sc	10	5	15	5	10	5	10	10	20	10
Sr	100	<100	<100	<100	<100	<100	<100	<100	<100	<100
Ti	3,000	3,000	3,000	2,000	3,000	2,000	5,000	5,000	5,000	3,000
V	100	50	100	150	70	300	70	70	150	70
Y	50	20	30	20	50	150	20	20	50	20
Zr	100	200	100	100	150	150	200	200	200	150

Table 76. *(Continued)*

	MHK 787	MHK 788	MHK 789	MHK 790	MHK 791	MHK 792	MHK 793	MHK 794
Ag	15	<.5	<.5	20	20	20	10	.5
Al	70,000	50,000	40,000	50,000	70,000	50,000	50,000	60,000
B	15	20	15	15	15	20	30	20
Ba	100	150	100	300	100	200	200	150
Be	2	2	1	1	1	2	2	2
Ca	3,000	20,000	50,000	1,000	7,000	3,000	500	2,000
Co	10	15	5	15	15	15	15	15
Cr	100	150	100	150	100	100	100	70
Cu	1,500	50	30	10,000	3,000	20,000	700	500
Fe	10,000	20,000	10,000	15,000	10,000	15,000	20,000	15,000
La	<20	20	50	20	70	50	20	20
Li	<100	<100	<100	<100	<100	<100	<100	<100
Mn	1,000	1,000	2,000	300	1,500	700	300	1,000
Mo	10	10	<5	<5	10	50	15	<5
Na	15,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000
Nb	<10	<10	<10	<10	<10	<10	<10	<10
Ni	20	30	15	30	30	30	50	30
Pb	2,000	100	30	30	2,000	500	700	50
Sb	<100	<100	<100	<100	<100	<100	<100	<100
Sc	5	10	5	5	10	10	10	10
Sr	<100	100	200	<100	<100	<100	<100	<100
Ti	1,500	3,000	1,000	3,000	3,000	3,000	3,000	3,000
V	20	70	20	70	100	150	100	70
Y	10	20	20	20	30	70	10	10
Zr	100	200	70	200	200	200	150	70

The following analyses of Catskill Formation channel samples were obtained via emission spectrographic analysis by Skyline Laboratories, Inc. All results for the following elements were less than their detection limits, which are indicated, in parts per million, in parentheses: bismuth (10), cadmium (50), germanium (20), antimony (100), tin (10), tungsten (50), and zinc (200). All data listed below are in parts per million unless otherwise noted.

	PRS-1	PRS-2	PRS-3	PRS-4	PRS-5	PRS-6	PRS-7	PRS-8	PRS-9
Ag	20	<1	<1	1	5	1.5	10	2	5
As	<500	<500	<500	<500	<500	<500	<500	<500	700
B	50	20	20	70	20	70	50	50	200
Ba	300	300	100	500	150	1,000	500	200	700
Be	<2	<2	<2	2	<2	2	2	<2	5
Ca	10%	0.7%	0.1%	0.05%	>20%	0.1%	0.2%	0.1%	0.1%
Co	10	5	20	20	5	30	20	<5	20
Cr	30	10	10	70	10	100	50	15	100

Cu	5,000	1,000	200	100	2,000	2,000	5,000	500	5,000
Fe	2%	1%	1.5%	5%	1%	3%	3%	2%	5%
Ga	10	10	10	30	<10	20	20	15	15
La	50	50	50	70	50	20	20	50	20
Mg	0.5%	0.2%	0.2%	1%	0.7%	2%	1%	0.2%	2%
Mn	3,000	3,000	1,000	500	10,000	1,000	1,500	500	700
Mo	<2	<2	<2	2	<2	<2	<2	5	<2
Nb	20	20	20	20	<20	20	20	<20	20
Ni	30	20	20	50	10	70	50	5	50
Pb	100	10	500	2,000	50	20	20	10,000	500
Sc	10	<10	<10	20	<10	30	20	<10	20
Sr	100	100	100	100	300	100	<100	<100	<100
Ti	7,000	7,000	5,000	7,000	3,000	5,000	7,000	3,000	7,000
V	70	50	70	100	70	150	200	100	500
Y	50	10	<10	20	50	20	50	<10	50
Zr	200	150	150	300	20	150	200	200	200

Table 77. *Selected Geochemical Analyses for Silver, Molybdenum, Selenium, and Vanadium*

Because of project limitations, quantitative trace-element analyses for silver, molybdenum, selenium, and vanadium were only requested (1) for those samples found to be highly enriched in uranium or copper; (2) those high in the element of interest based on the semiquantitative analyses; or (3) those from an unusual occurrence. All data are based on commercial, "geochemical"-quality analyses. Multiple values represent replicate analyses of the same sample pulps.

	MHK 728	MHK 730	MHK 733	MHK 742	MHK 745	MHK 747	MHK 748
Ag (troy oz/ton)	1.66	—	—	.50	.44	—	2.01
Mo (ppm)	—	10	5	<2	24	—	—
Se (ppm)	7	<.1	.4	—	—	2	—
V (ppm)	—	255	300, 780	500	—	700	—

Table 77. *(Continued)*

	MHK 755	MHK 758	MHK 770	MHK 776	MHK 780	MHK 781	MHK 782
Ag (troy oz/ton)	1.43	—	—	—	—	—	—
Mo (ppm)	—	—	42	—	14	3	33
Se (ppm)	—	2	—	3	8,6	.2	6
V (ppm)	—	—	—	295	225	78	820, 840
	MHK 786	**MHK 790**	**MHK 791**	**MHK 792**	**PRS-3**	**PRS-4**	**PRS-8**
Ag (troy oz/ton)	.52	.79	.67	.96	—	—	—
Mo (ppm)	—	—	—	50	—	—	—
Se (ppm)	—	—	—	—	2	1	2
V (ppm)	—	—	—	—	—	—	—

Au content of MHK 728, 742, 745, 758, 790, 791, and 792 was less than 0.003 troy oz/ton; Au content of MHK 755 and 786 was at detection limit of 0.003 troy oz/ton.

APPENDIX 4. STATISTICAL STUDIES AND GEOCHEMICAL INTERPRETATIONS

Correlation Coefficients of Channel-Sample Analyses

The correlation coefficient *r* measures the degree to which a pair of variables vary sympathetically, that is, how closely two elements tend to follow or avoid one another. If they exactly follow or avoid one another, *r* will equal +1 or −1, respectively. As the variation becomes more random, *r* approaches zero. Correlation coefficients were calculated for pairs of elements and for some other factors, such as elevation, that were obtained for each channel sample. One set of correlation coefficients was generated from the data for all channel samples regardless of lithology and three separate sets were generated for subgroups based on lithologic classification as calcareous breccia, sandstone, and siltstone plus shale. In essence, these correlation coefficients tell which elements and properties were consistently enriched or depleted together in the same samples. The calculations and scatter diagrams were obtained by J. H. Barnes using the Pennsylvania Geological Survey's correlation and plotting programs on a 48K microcomputer.

The "latitude" and "longitude" numbers used for these calculations are the number of seconds north of the southern boundary of the study area (41°15′00″N) and west of the eastern edge (76°30′00″W). They constitute an attempt to mathematically represent sample sites without masking small differences between the numerically larger actual latitude and longitude readings. The values for elevation represent an attempt to quantify relative stratigraphic position within the Catskill Formation. Elevation data were used as a substitute for structure-contour data, which were not obtained because of time limitations, low bedding dips, crossbedding, and lack of good marker horizons. The values for grain size represent an attempt to quantify lithology. To obtain the values, a grain size of 2,000 μm was assigned to all calcareous breccias, 200 μm to all sandstones, and 4 μm to all siltstone and shale samples. It should be noted that these figures do not represent actual measurements of grain size, but are only a somewhat arbitrary assignment based on initial field classification of the dominant lithology.

In addition to real affinities, apparent strong correlations of geochemical data could have been due to any or all of the following processes:

(1) Possible analytical interferences; for example, an emission spectroscopy line for boron could possibly have had an interference from iron.

(2) Possible ineffective normalization via an internal standard to a constant "exposure" for the elements determined by the I.C.P. emission spectrometer procedure. Correlations of I.C.P.-determined elements with those done by independent methods, such as arsenic, copper, uranium, and lead, should not, however, have this problem.

(3) The undue influence of a few outlying samples that have unusually high concentrations of both elements being correlated. Scatter diagrams were plotted to evaluate this effect for each pair discussed below. Pairs that had suspicious scatter diagrams were recalculated

Table 78. *Correlation Coefficients (r)*

$r = \frac{\Sigma xy}{\sqrt{\Sigma x^2 \Sigma y^2}}$, where r = the correlation coefficient;

Σxy = the sum of the product of two variables, such as parts per million copper and parts per million U_3O_8; and

$\sqrt{\Sigma x^2 \Sigma y^2}$ = the square root of the sum of the squares of the two variables.

	Lat.	Long.	Elev.	Grain size	U_3O_8	Cu	As	Pb	Ag	8	8a	8e	Ca	Co
Zr	-.0984	-.0311	.0000	-.1648	.6197	.0000	.2244	.0000	-.1278	-.3130	-.0974	-.1212	-.2216	-.1280
Y	.0000	-.2050	.0260	.1117	.7651	.2065	.4430	-.0424	.2100	-.0944	.1519	.1333	.0178	.2484
V	.3097	-.3423	.2125	.0369	.3008	.1685	.2791	.1002	.3353	.3776	.5825	.5104	-.1128	.5858
Ti	.0957	-.0762	.0972	-.1854	.4355	-.0497	.1690	-.0790	-.0488	.0587	.1923	.1971	-.1491	.1332
Sr	.0457	.1019	-.0659	.5797	-.1590	-.1263	-.1487	-.1711	-.1626	-.2245	-.1245	-.2700	.7310	-.3170
Sc	-.0234	-.1042	-.0427	-.2307	.2109	.0203	.1228	-.1685	.0533	.1686	.3539	.4043	-.1847	.2810
Sb	-.0883	.0902	-.1029	-.0737	.1974	.1497	.4384	.0730	.4233	.3457	.2698	.4485	-.0145	.3705
Ni	-.1000	.0471	-.2649	-.3984	.0532	.0688	.1061	-.1375	.2558	.6278	.4556	.7671	-.3265	.7034
Nb	.2193	-.0843	.1701	-.1226	.2667	-.1383	.0494	-.0916	-.1262	-.0228	.0168	-.0918	-.0354	-.1009
Mo	-.1636	.1207	-.2614	-.1485	.1254	.2659	.3179	.2334	.3530	.4722	.2096	.4793	-.1641	.4198
Mn	.0579	.0356	-.0651	.6439	-.2190	-.0201	-.1489	-.1710	.0178	-.0746	-.0573	-.1414	.8243	-.1932
La	.0241	-.1413	.0527	.3582	.1281	.0000	.0393	-.0310	-.0789	-.1696	.1070	-.1420	.2341	.0000
Fe	.1781	-.1114	-.0616	-.3903	.0923	-.0268	.1164	.0539	.2160	.8220	.4679	.7723	-.2744	.6642
Cr	-.2500	.3457	-.4125	-.3355	-.0107	.1574	.0779	-.0605	.1952	.3747	.2145	.5544	-.3065	.5016
Co	.1308	-.1274	-.0828	-.2712	.1357	.1108	.2059	.0949	.3546	.6065	.4921	.7574	-.2836	1.0000
Ca	.0000	.0653	-.0612	.6461	-.1536	-.0952	-.1106	-.1728	-.0895	-.1743	-.1479	-.2700	1.0000	
8e	-.0906	.0620	-.2536	-.2757	.2135	.1758	.2963	-.0136	.4104	.8156	.5331	1.0000		
8a	.2557	-.2335	.1742	-.1356	.1966	.1271	.0686	-.0709	.2167	.4422	1.0000			
8	.0113	.0834	-.2463	-.2399	.0376	.0606	.1603	.0579	.2672	1.0000				
Ag	-.0470	.1731	-.1443	-.0717	.2420	.6079	.5045	.0908	1.0000					
Pb	.2143	-.0274	.1563	-.0974	.0181	-.0675	.1280	1.0000						
As	-.2221	.1312	-.1068	-.0747	.6585	.3786	1.0000							
Cu	-.2137	.1436	-.1649	-.0505	.1976	1.0000								
U_3O_8	-.0965	-.0876	.0343	-.1562	1.0000									
Grain size	-.1599	.0836	-.1707	1.0000										
Elev.	.5890	-.5669	1.0000											
Long.	-.5060	1.0000												
Lat.	1.0000													

Note: The twelve zero values are actually <.01 and >-.01.

without using the 1 to 3 outlying values and deleted from discussion if no longer significant.

(4) The tendency for richer occurrences to be enriched in introduced "byproduct" elements as well as copper and U_3O_8. Normalization to an introduced element such as copper should be considered.

Because each of the processes tends to enhance "real" correlations, only those values of $|r| \geq 0.6$ have been underlined in the tables, and, in general, only those pairs that have $|r| \geq 0.7$ are discussed. These cutoff values were arbitrarily chosen in an effort to reduce the number of pairs to a manageable number and to focus on those processes likely to be most important.

for 78 Channel and Dump Samples

Values of $|r| \geq 0.6$ are underlined. Values of $|r| \geq 0.29$ are theoretically significant at the 99 percent confidence interval.

	Cr	Fe	La	Mn	Mo	Nb	NI	Sb	Sc	Sr	TI	V	Y	Zr
Zr	-.0212	-.1257	.3190	-.3462	-.2316	.4569	-.0622	-.1391	.3794	-.1403	.7184	.0102	.6048	1.0000
Y	-.0885	-.0374	.3614	.0000	.0723	.2099	-.0283	-.0614	.2083	.0000	.4839	.5112	1.0000	
V	.1867	.4311	.1105	-.0291	.2037	.0495	.2767	.0326	.1914	-.1390	.2768	1.0000		
TI	.0389	.2355	.2312	-.2139	-.1382	.7016	.2522	-.0724	.5430	-.0720	1.0000			
Sr	-.2435	-.2621	.2278	.7059	-.2022	.1596	-.2847	-.0676	-.0882	1.0000				
Sc	.3971	.3421	.0650	-.2542	.0000	.3870	.6107	.2468	1.0000					
Sb	.1952	.3323	-.0468	.0000	.4514	-.0969	.3366	1.0000						
NI	.6942	.7297	-.1987	-.3039	.2955	.0862	1.0000							
Nb	-.1799	.1362	.0000	-.0800	-.2769	1.0000								
Mo	.2494	.3831	-.0941	-.1201	1.0000									
Mn	-.3338	-.2327	.2350	1.0000										
La	-.2070	-.1422	1.0000											
Fe	.4760	1.0000												
Cr	1.0000													

All Lithologies

The calculated values for the correlation coefficients for all lithologies together appear in Table 78.

Because the values of Table 78 are derived from three different lithologies, correlations are probably masked by lithologic variation. Twelve pairs have $r \geq 0.7$. In theory, numbers larger than 0.29 are significant at the 99 percent confidence interval for 78 samples. Pairs that are possibly significant include U_3O_8-Y, B-Be, B-Fe, Be-Ni, Be-Fe, Be-Co, Ca-Sr, Ca-Mn, Co-Ni, Mn-Sr, Nb-Ti, and Ti-Zr. When correlation coefficients are calculated by individual lithologies, most of these same pairs have higher apparent values of r.

Table 79. *Correlation Coefficients (r)*

Values of $|r| \geq 0.6$ are underlined. Values of $|r| \geq 0.59$ are

	Lat.	Long.	Elev.	U_3O_8	Cu	As	Pb	Ag	B	Ba	Be	Ca	Co
Zr	-.2257	.0321	.0264	.4961	.2621	.1039	.0732	.0226	-.2732	.1678	-.0149	-.2920	.0000
Y	.5987	-.5040	.6113	.8592	.4697	.8562	.6936	.7200	.3019	.7535	.5471	-.2187	.7607
V	.5743	-.4797	.5087	.7398	.4588	.9132	.7317	.8216	.4989	.7418	.6482	-.3051	.8524
Ti	.0731	.1072	.2385	.6944	.4098	.3755	.3525	.3948	.1148	.3765	.2967	-.0235	.3416
Sr	.2737	.1161	.1297	-.2068	-.1437	-.2971	-.3812	-.1568	-.2019	-.2400	-.2293	.6483	-.3152
Sc	-.1801	-.1519	.0860	.4377	.1035	.1848	.1001	-.0329	-.0976	.3443	.1459	-.2172	.1908
Sb	-.3162	-.0145	-.1023	-.1490	.0000	-.0644	-.1212	-.0677	.3254	.1927	.3173	-.0879	.1083
Ni	-.0522	.1528	-.1633	.3565	.3668	.4395	.4530	.4137	.6952	.5628	.7178	-.4715	.6698
Nb	-.0546	.5642	-.0362	-.0430	-.0977	-.0875	-.1083	.2239	-.0122	-.0761	-.2360	.2511	-.1304
Mo	.2224	-.2155	.1644	.3086	.5714	.4376	.2901	.6689	.5843	.3363	.5617	-.2692	.4716
Mn	.2764	.0527	.2047	-.4024	-.2324	-.3146	-.3152	-.1166	-.1093	-.2861	-.2473	.7283	-.3416
La	.2248	-.4098	.2966	.2447	-.1441	.1146	.1993	-.1931	-.3298	.3281	-.0885	-.2060	.1125
Fe	.0949	.0146	.0226	.3158	.2792	.5362	.5375	.5436	.8362	.6941	.7749	-.2929	.7540
Cr	.1371	-.0995	-.0370	.2839	.2136	.5176	.5373	.3780	.6631	.6355	.6959	-.4749	.7508
Co	.3636	-.3114	.2683	.6187	.2921	.9119	.8856	.5640	.6707	.8776	.8084	-.4133	1.0000
Ca	.2730	.0941	.4419	-.3675	-.3256	-.3136	-.3325	-.1719	-.3913	-.4769	-.5356	1.0000	
Be	.1044	-.0914	-.0480	.5883	.5595	.6019	.6672	.5095	.8616	.7591	1.0000		
Ba	.3028	-.2676	.2203	.5578	.1714	.7586	.7518	.4482	.5650	1.0000			
B	.0845	.1502	-.2169	.2478	.3575	.4203	.5737	.4726	1.0000				
Ag	.4434	-.1187	.4043	.6542	.6715	.6507	.3993	1.0000					
Pb	.3920	-.2436	.2537	.5335	.2182	.8186	1.0000						
As	.4146	-.4680	.4471	.7206	.3338	1.0000							
Cu	.0467	-.0930	.1324	.7455	1.0000								
U_3O_8	.2787	-.4104	.3855	1.0000									
Elev.	.6778	-.5955	1.0000										
Long.	-.3480	1.0000											
Lat.	1.0000												

Note: The seven zero values are actually <.01 and >-.01.

Calcareous Breccia

The calculated values of *r* for all calcareous breccia samples appear in Table 79. There are 34 pairs that have $r \geq 0.7$. In theory, numbers larger than 0.59 are significant at the 99 percent confidence interval for 17 samples. Note that elevation shows a weak positive correlation with latitude and a weak negative correlation with longitude. This may be a complicated way of saying that the edge of the plateau slopes to the south and that North Mountain occurs in the eastern portion of the project area.

1. (1) Ca-Mn and Mn-Sr simply suggest that early formed calcite in the calcareous breccia is an efficient collector of Mn and Sr.
2. (2) Cr-Fe, Cr-Ni, Fe-Ni, Co-Fe, and Co-Cr may reflect the well-known geochemical coherence of Cr, Co, Fe, and Ni in selected environments, such as adsorption on iron oxides in the original sediments. Correlations may also result from dilution by "pure" calcite. Scatter diagrams confirm the suspiciously strong correlations.

for 17 Calcareous Breccia Samples

theoretically significant at the 99 percent confidence interval.

	Cr	Fe	La	Mn	Mo	Nb	Ni	Sb	Sc	Sr	Ti	V	Y	Zr
Zr	-.1475	-.1284	.5060	-.6157	-.3556	.3287	.1148	-.1393	.7992	-.2880	.7219	.0000	.2744	1.0000
Y	.3579	.4332	.3471	-.2020	.3671	.0000	.3010	-.1753	.2948	-.1155	.5704	.9008	1.0000	
V	.5183	.5728	.0810	-.2076	.5561	-.1005	.4056	-.0819	.0749	-.2743	.3350	1.0000		
Ti	.0664	.2696	.2429	-.3571	-.1481	.5497	.3123	-.1522	.6449	-.1040	1.0000			
Sr	-.2808	-.1871	-.0918	.7496	-.0979	.0000	-.2556	.0000	-.1364	1.0000				
Sc	.1052	.1667	.5662	-.5589	-.2053	.2422	.3121	.2918	1.0000					
Sb	.2279	.4136	-.1689	.0118	.4196	-.0625	.3002	1.0000						
Ni	.9017	.8553	.0000	-.4978	.4517	.0488	1.0000							
Nb	-.2002	.1031	-.1009	-.1022	-.1875	1.0000								
Mo	.5154	.5973	-.2919	.0198	1.0000									
Mn	-.3876	-.1898	-.3986	1.0000										
La	.0839	-.1199	1.0000											
Fe	.8440	1.0000												
Cr	1.0000													

(3) B-Fe, B-Be, and Be-Fe may result from mutual enrichment in marine-influenced sediments (note, however, the absence of a strong negative correlation between B and elevation), enrichment in a fine-grained, clay-rich component, or, especially in the case of B-Fe, from analytical interference in the emission spectrographic procedure.

(4) Sc-Zr may result from sympathetic, relative enrichment in heavy minerals such as zircon.

(5) U_3O_8-As is a classical correlation in some sandstone and red-bed deposits.

(6) Cu-Ag reflects substitution of Ag into Cu sulfides. There is a suggestion that rich samples tend to be richer in both "ore" and selected "byproduct" elements, as perhaps also illustrated in (5) above.

(7) Co-V, Co-Pb, and Co-Ba suggest that Co was introduced with the ore-forming process. The combination V, Pb, and Co, unusual in calcareous sediments, feebly suggests that these elements were intro-

Table 80. *Correlation Coefficients (r)*

Values of $|r| \geq 0.6$ are underlined. Values of $|r| \geq 0.37$ are

	Lat.	Long.	Elev.	U_3O_8	Cu	As	Pb	Ag	8	8a	8e	Ca	Co
Zr	-.1496	-.0231	-.1076	.6846	-.0782	.2597	-.0613	-.1502	-.4071	-.1412	-.1699	-.1288	-.1835
Y	-.1126	-.1488	-.0535	.8529	.0928	.3750	-.1570	.0856	-.1696	.0656	.0765	-.1335	.1813
V	.1783	-.3328	.2448	.3914	.0998	.0509	-.1043	.1832	.3699	.7402	.5353	-.0801	.5115
Ti	-.0643	-.0503	-.0438	.5229	-.1485	.1449	-.2310	-.1557	-.1302	.1022	.0886	-.0636	-.0458
Sr	.2218	-.0346	.2897	-.0800	-.1407	-.1055	-.0706	-.1557	-.1890	-.0972	-.2733	-.0721	-.2095
Sc	-.0983	-.1040	.0000	.3358	-.0214	.1667	-.1988	.2068	.0126	.3037	.3932	.0210	.1782
Sb	.0230	.0853	-.0805	.2560	.0865	.5231	.1247	.5088	.2965	.2059	.4256	.1113	.3153
Ni	-.3748	.1662	-.4004	.0801	.1675	.1437	-.2452	.4067	.6242	.4201	.8127	.0495	.7136
Nb	.1111	-.0777	.1493	.3665	-.1194	.0880	-.1256	-.1490	-.2177	-.0818	-.1747	-.1776	-.1868
Mo	-.2496	.1676	-.3848	.0643	-.0385	.2526	.2300	.2476	.5409	.1800	.5094	-.0984	.4293
Mn	.2236	.0447	.0147	-.2758	.0391	-.2409	-.1590	.1306	.1142	.0562	.0803	.6375	.0622
La	.0549	-.1985	.0000	.2389	-.1941	.0000	-.1122	-.1353	-.0756	.1152	-.0832	.2561	.1235
Fe	-.0240	-.0848	-.1837	.0668	.0122	.0715	-.0209	.2543	.8108	.4258	.7841	.1827	.6666
Cr	-.4219	.4560	-.4860	-.0448	.2878	.0491	-.0933	.3203	.3261	.1531	.5094	.0312	.4783
Co	.0000	-.0764	-.1925	.1497	.0730	.0431	-.0876	.3425	.5214	.3839	.6518	.0765	1.0000
Ca	.0731	-.0301	-.0706	-.1580	-.2406	-.0954	-.2417	-.1379	.2269	.0000	.0931	1.0000	
8e	-.3158	.1709	-.3291	.2347	.1501	.2754	-.1242	.4765	.7662	.4903	1.0000		
Ba	.2371	-.2828	.1969	.1883	.1083	-.0790	-.1523	.1656	.3660	1.0000			
8	-.2276	.1675	-.3378	-.0126	.0766	.0983	.0154	.2742	1.0000				
Ag	-.1458	.2863	-.2845	.1973	.7558	.4605	.0282	1.0000					
Pb	.1619	.0417	.0647	-.0286	-.1301	.0664	1.0000						
As	-.3607	.2410	-.1888	.6643	.2666	1.0000							
Cu	-.1405	.2688	-.2286	.0891	1.0000								
U_3O_8	-.1691	-.0436	-.0299	1.0000									
Elev.	.5937	-.5768	1.0000										
Long.	-.5673	1.0000											
Lat.	1.0000												

Note: The seven zero values are actually <.01 and >-.01.

duced late, i.e., after sedimentation, and that they do not merely represent remobilization from within a calcareous breccia.

Sandstone

The correlation coefficients for sandstone samples appear in Table 80. There are 11 pairs that have $r \geq 0.7$. In theory, numbers larger than 0.37 are significant at the 99 percent confidence interval for 46 samples. Some of the pairs that have high correlation coefficients are discussed below.

(8) Zr-Ti and Y-U_3O_8 may result from two or more discrete processes: first, relative enrichment of heavy, detrital minerals such as zircon, ilmenite, rutile, and titanite and, second, efficient collection of Y and possibly U on finely divided titanium oxides such as might form via alteration of ilmenite, titanite, etc. A detrital U_3O_8-bearing rare-earth heavy mineral likewise cannot be ruled out. Note also that Y-U_3O_8 is the strongest correlation (r = 0.85) within the sand-

for 46 Sandstone Samples

theoretically significant at the 99 percent confidence interval.

	Cr	Fe	La	Mn	Mo	Nb	Ni	Sb	Sc	Sr	Ti	V	Y	Zr
Zr	-.1117	-.3025	.4430	-.2201	-.2652	.4867	-.1805	-.1225	.3480	.0233	.7409	.0358	.7701	1.0000
Y	-.1254	-.0565	.3388	-.1751	-.0127	.3682	.0000	-.0657	.3441	-.1258	.5823	.3363	1.0000	
V	.1796	.5694	.1283	-.0470	.0828	.0353	.3949	.0391	.3014	-.1309	.2133	1.0000		
Ti	-.1279	-.0139	.3995	.0771	-.1629	.7527	.1008	-.0886	.4643	.3458	1.0000			
Sr	-.3895	-.2246	.1270	.2297	-.1784	.6908	-.2703	-.0551	-.1789	1.0000				
Sc	.2075	.1370	.1567	.0582	.0715	.2135	.4440	.2861	1.0000					
Sb	.1780	.3482	-.1089	-.0586	.4505	-.0798	.3488	1.0000						
Ni	.6699	.6863	-.0361	.0594	.3965	-.1360	1.0000							
Nb	-.3722	-.1510	.1325	.0977	-.2582	1.0000								
Mo	.2141	.4687	-.1157	-.1932	1.0000									
Mn	-.0218	.0777	.2135	1.0000										
La	-.1096	.0000	1.0000											
Fe	.3772	1.0000												
Cr	1.0000													

stones. Removal of two outlying Y values of $\geq$ 175 ppm yields a lower *r* of only 0.4865, but 0.38 would still be significant at the 99 percent confidence interval.

(9) Co-Ni, Co-Cr, and similar, weak correlations, see (2) above.

(10) B-Fe and B-Be, see (3) above.

(11) Ag-Cu, see (6) above and note that this correlation is stronger than that in calcareous breccia, but not as strong as in siltstone plus shale.

(12) Of particular note is the independence of Cu from U_3O_8, possibly implying two separate stages of mineralization for these elements in sandstones.

Siltstone and Shale

The correlation coefficients for siltstone and shale samples appear in Table 81. Because only 13 samples are included, the interpretations listed be-

Table 81. *Correlation Coefficients (r)*

Values of $|r| \geq 0.6$ are underlined. Values of $|r| \geq 0.66$ are

	Lat.	Long.	Elev.	U_3O_8	Cu	As	Pb	Ag	B	Ba	Be	Ca	Co
Zr	.1829	-.4546	.8968	.3085	.0625	.0799	.7073	-.2481	-.4020	-.3299	-.6233	-.4202	-.6710
Y	-.5306	.2291	.0126	.8724	.7641	.8536	-.0216	.7012	-.2219	.1469	-.1945	.1510	-.3452
V	.2781	-.0696	-.0408	.6248	.0888	.6020	-.1901	.2589	.6437	.4232	.4285	.1933	.0711
Ti	.5818	-.4566	.8489	.1464	-.3475	.0653	.4313	-.3661	.1406	.1095	-.2040	-.2710	-.3163
Sr	.5021	-.3719	.7630	-.3589	-.2853	-.2837	.4837	-.4424	-.2700	.1127	-.5324	-.3002	-.2112
Sc	.4485	-.3331	.5251	-.2707	-.4869	-.1833	-.1151	-.4086	-.0227	.3932	-.2677	-.2054	-.0781
Sb	-.3674	.4906	-.3350	.0000	.2512	.4382	.0495	.7050	.3961	.5411	.6084	.9911	.7901
Ni	.2621	.0838	-.3191	-.7627	-.6237	-.4962	-.4192	-.2545	.3654	.3643	.4294	.2527	.6682
Nb	.7430	-.6505	.7716	.0434	-.3381	-.0737	.3772	-.4887	.0550	.1188	-.3651	-.3846	-.3560
Mo	-.5764	.6090	-.5330	.4524	.8554	.6077	.0467	.8210	.1137	.1287	.3274	.5526	.3512
Mn	-.1776	.5258	-.3508	.0545	.3055	.5154	-.0375	.6968	.5409	.7206	.6437	.9142	.8336
La	-.3121	.4889	.4180	.1973	.4357	.4815	.6203	.4915	-.1794	.1628	-.1102	.3018	-.0127
Fe	.7711	-.0704	.2408	-.2248	-.4683	-.1031	.2900	-.2930	.7680	.2789	.5208	.0843	.3896
Cr	-.3667	.2982	-.4950	-.1639	-.1480	-.1876	-.5778	.0248	.2159	-.0507	.4715	.1873	.4319
Co	-.0558	.4935	-.5172	-.3842	-.1015	.0231	-.1771	.3334	.6440	.5078	.8241	.8022	1.0000
Ca	-.4093	.4807	-.4125	.0225	.2976	.4159	.0466	.7125	.3933	.4640	.6315	1.0000	
Be	.0682	.4620	-.5982	-.0891	-.1109	.1473	-.2565	.2846	.8854	.3697	1.0000		
Ba	.1949	.5043	-.0740	.0000	.0627	.5174	-.2549	.4582	.4851	1.0000			
B	.4734	.2468	-.3203	.0000	-.2106	.1955	-.1602	.0997	1.0000				
Ag	-.6093	.6536	-.4016	.5258	.8088	.8472	-.0231	1.0000					
Pb	.1631	-.1848	.6317	.0413	.1440	.0459	1.0000						
As	- 2707	.4313	-.0835	.7953	.7621	1.0000							
Cu	-.5762	.3602	-.2429	.7263	1.0000								
U_3O_8	-.2464	-.0394	-.0195	1.0000									
Elev.	.4083	-.4395	1.0000										
Long.	-.3761	1.0000											
Lat.	1.0000												

Note: The three zero values are actually <.01 and >-.01.

low should be considered very tentative. There are 37 pairs that have $|r| \geq 0.7$. In theory, numbers larger than 0.66 are significant at the 99 percent confidence interval for 13 samples.

(13) Zr-elevation, Ti-elevation, and Ti-Zr suggest detrital heavy minerals and their possible enrichment in the coarser grained upper portion of the Catskill Formation.

(14) U_3O_8-As and U_3O_8-Cu, see (5) above.

(15) Cu-Ag, As-Ag, see (6) above. Also, tennantite might carry Ag as well as As.

(16) B-Fe and B-Be, see (3) above.

(17) Y-U_3O_8, Y-As, and Y-Ag, all of which are possible correlations, very weakly suggest introduction of Y during an ore-forming process. Apparent strong similar correlations for calcareous breccias become less apparent when outlying high Y values are excluded.

(18) Mo-Ag, Mo-Cu, and possible weak correlations of Mo with As, longitude, latitude (−), and elevation (−) suggest that Mo was en-

for 13 Siltstone Plus Shale Samples

theoretically significant at the 99 percent confidence interval.

	Cr	Fe	La	Mn	Mo	Nb	Ni	Sb	Sc	Sr	Ti	V	Y	Zr
Zr	-.4703	.0679	.4943	-.4292	-.2716	.6245	-.6718	-.3830	.2366	.5368	.7491	.0157	.2725	1.0000
Y	-.0964	-.4758	.4507	.1378	.4723	-.1439	-.7204	.1648	-.1925	-.3388	.0487	.4300	1.0000	
V	-.0167	.3888	-.1115	.3177	.0212	.2956	-.1552	.2258	.1127	-.3118	.4405	1.0000		
Ti	-.3136	.5374	.2344	-.1566	-.5477	.8350	-.2197	-.1887	.5592	.5250	1.0000			
Sr	-.5507	.2020	.1682	-.1394	-.4587	.7638	.0368	-.2500	.7093	1.0000				
Sc	-.2057	.1341	-.1374	-.0116	-.6366	.7137	.2321	-.1281	1.0000					
Sb	.1632	.1185	.3418	.9227	.4849	-.3273	.2762	1.0000						
Ni	.3650	.3476	-.4786	.3125	-.2989	-.1125	1.0000							
Nb	-.5875	.4340	-.0711	-.2004	-.6006	1.0000								
Mo	.1928	-.2342	.3872	.5518	1.0000									
Mn	.1556	.2388	.2639	1.0000										
La	-.1773	-.0158	1.0000											
Fe	-.0166	1.0000												
Cr	1.0000													

riched very early in the lower Catskill siltstones and shales exposed in the more southwesterly occurrences. Mo, Cu, and As are well known for their enrichment in black shales, and weak correlations of Ag with longitude and latitude (−) also very weakly support black shale accumulation. These correlations tend to support remobilization of some elements within the sedimentary host rock.

(19) Ni-Y (−), Ni-U_3O_8 (−), Ni-Zr (−), and, more weakly, Ni-Cu (−) suggest that Ni might have been removed rather late by solutions bringing in "ore" metals.

Means, Standard Deviations, and Medians of Channel-Sample Analyses

Means and Standard Deviations

Mean and standard-deviation data for the channel-sample analyses have been calculated for both lithologic and deposit cluster groupings (Table 82).

Table 82. *Data on Means and Standard Deviations for Lithologic Groups and Clusters*

Data are reported in parts per million unless otherwise indicated.

Lithology	No. of samples	U_3O_8	Cu	As	Pb	Ag	Al[1] (%)	B	Ba	Be	Ca (%)	Co	Cr
					LITHOLOGIC GROUPS								
Calcareous breccia	17	72±101	5,256±4,748	156±216	546±1,064	10±11.1	5.2±3.3	52±36	382±270	2±2	5.54±4.44	18±15	49±23
All sandstone	46	230±218	4,967±6,740	203±406	1,072±1,968	12.5±17	7.1±4.1	69±55	439±523	2±2	.58±.53	22±10	69±32
"Nonmaroon" sandstone	36	135±246	5,097±7,246	206±421	1,049±1,618	13.6±18.9	7.2±4.4	79±55	403±370	2±2	.59±.52	22±9	76±32
"Maroon" sandstone	11	541±894	5,593±5,460	217±337	1,125±2,761	11.7±2.9	6.6±2.9	38±41	560±823	2±2	.86±1.12	22±13	46±19
Siltstone and shale	13	193±242	8,623±14,741	201±314	359±437	10.1±8.3	8.4±5.9	105±65	745±587	4±2	.47±.59	29±13	107±24
All[1] (mean)	77	181±421	5,579±848	195±355	821±1,643	11.0±14.7	7.6±3.8	67±56	440±459	2±2	1.73±2.99	22±12	71±36
All[1] (median)	77	43	2,950	70	110	7	6.5	50	.305	2	.65	20	70
Cluster name					CLUSTERS								
Rock Run	6	60±86	6,133±10,933	53±38	1,379±1,857	24.0±31	10.1±5.1	148±37	523±239	5±2	.91±1.38	32±12	92±37
Fox Run Valley	10	79±114	8,509±10,333	176±301	702±969	13.0±9.6	8.0±3.8	66±49	462±411	2±2	2.05±2.87	20±10	89±30
Strawbridge	6	102±127	6,273±6,150	188±163	1,213±845	13.3±15.8	5.4±0.8	108±46	304±60	3±0	1.87±1.58	24±4	81±32
Beaver Lake	14	374±810	8,302±12,841	276±338	370±706	7.7±4.8	7.1±3.6	53±49	348±160	3±2	1.86±2.17	21±12	70±39
McCauley 22	4	470±535	10,125±5,284	928±901	944±259	31.8±18.9	8.6±3.8	93±38	333±77	4±1	.33±.38	26±8	95±6
Sonestown Nose A	2	318±308	1,673±1,528	273±247	133±118	2.5±2.5	---	150±50	595±105	4±1	.47±.37	23±3	90±10
Sonestown Nose B	6	115±119	4,359±5,822	252±331	932±1,488	12.4±16.9	6.0±0.9	64±56	499±360	2±2	2.43±2.41	30±19	68±20
Sonestown Nose C	3	38±11	8,733±5,855	68±62	18±8	9.7±3.8	4.3±.5	12±2	267±47	0±0	.33±.12	10±4	23±5
Muncy Valley	9	56±77	2,250±1,834	61±63	53±85	4.3±4.1	7.1±3.4	37±32	424±271	1±2	1.91±2.30	17±8	55±25
Front	3	29±27	795±994	33±27	822±641	2.0±2.1	---	37±24	250±178	1±1	7.05±9.86	15±7	30±28
North Mountain	2	30±27	1,260±990	20±10	113±108	1.5±0.5	11.6±3.4	106±20	455±35	3±1	.47±.25	25±7	75±23
Old/New U.S. 220	5	505±320	3,354±2,441	87±83	2,358±3,730	12.8±4.9	8.4±3.4	57±56	1,262±1,245	2±2	.70±.71	33±11	60±22
"Miscellaneous"	7	63±115	2,244±3,194	119±91	1,549±2,709	5.9±8.6	7.4±3.9	34±28	189±83	1±1	1.34±1.60	11±7	73±46

Lithology	No. of samples	Fe (%)	La	Mn (%)	Mo	Na[1] (%)	Nb	Ni	Sb	Sc	Sr	Ti (%)	V	Y	Zr
LITHOLOGIC GROUPS															
Calcareous breccia	17	1.67±.79	57±18	.38±.19	10±13	.82±.38	2±4	28±10	8±30	5±5	101±72	.31±.18	189±296	49±40	105±72
All sandstone	46	2.42±1.11	41±15	.12±.08	15±18	.94±.34	3±5	35±12	11±37	6±5	23±16	.35±.15	140±130	34±48	139±102
"Nonmaroon" sandstone	36	2.54±1.13	41±14	.12±.08	17±19	.93±.38	3±5	38±12	13±41	5±5	24±18	.35±.12	120±82	23±18	127±56
"Maroon" sandstone	11	2.01±.87	42±17	.13±.12	10±15	.96±.13	3±5	27±9	1±0	6±5	27±23	.35±.23	273±281	78±83	169±181
Siltstone and shale	13	3.33±1.20	38±17	.09±.06	17±16	.67±.40	5±8	57±12	26±46	16±5	32±29	.41±.14	186±107	30±21	140±65
All[1] (mean)	77	2.34±1.19	44±18	.17±.16	14±17	.98±.22	3±6	36±15	11±36	7±7	45±23	.35±.16	153±180	36±43	133±92
All[1] (median)	77	2.00	50	.10	10	1.00	1	30	1	10	20	.30	94	21	100
Cluster name						CLUSTERS									
Rock Run	6	3.50±1.32	33±8	.19±.16	34±26	.78±.28	1±0	50±17	27±58	9±6	50±67	.28±.09	147±69	24±21	78±27
Fox Run Valley	10	2.09±.73	43±18	.20±.14	14±13	1.02±.19	3±6	35±10	12±33	5±6	41±43	.37±.15	94±78	27±18	128±52
Strawbridge	6	2.40±.31	42±8	.17±.09	14±4	.98±.24	1±0	40±6	1±0	3±3	20±0	.31±.10	127±84	24±6	95±48
Beaver Lake	14	2.01±.98	47±14	.17±.15	17±21	.94±.12	2±5	38±17	18±42	10±6	47±45	.38±.22	107±68	56±72	172±161
McCauley 22	4	2.92±.66	29±5	.07±.02	21±10	1.00±.13	1±0	49±1	45±76	6±5	20±0	.32±.04	144±26	22±7	113±22
Sonestown Nose A	2	4.27±.73	42±22	.13±.06	10±10	---	11±10	46±5	1±0	15±5	20±0	.55±.15	295±205	35±15	147±53
Sonestown Nose B	6	2.71±1.74	63±20	.20±.12	13±17	1.18±.35	1±0	32±7	1±0	4±4	47±38	.36±.12	420±413	68±59	124±50
Sonestown Nose C	3	1.50±.41	30±14	.09±.04	0±0	1.00±00	1±0	17±2	1±0	1±0	20±0	.23±.05	80±14	20±8	80±14
Muncy Valley	9	1.85±.96	48±25	.19±.14	4±8	.97±.21	5±8	35±17	1±0	9±10	47±38	.37±.17	117±86	35±18	180±79
Front	3	2.50±1.78	57±9	.38±.43	0±0	---	14±9	27±17	1±0	7±9	167±94	.50±.16	80±14	24±20	157±114
North Mountain	2	2.88±.54	36±11	.08±.01	18±2	1.09±.10	1±0	40±10	1±0	11±1	20±0	.30±.08	253±62	18±1	75±26
Old/New U.S. 220	5	2.58±1.18	44±13	.14±.09	14±11	.98±.03	1±0	37±13	22±42	7±5	20±0	.30±.10	310±261	60±48	119±27
"Miscellaneous"	7	1.68±.76	42±17	.15±.08	7±8	.98±.05	4±7	25±12	1±0	5±4	69±64	.32±.17	70±26	18±11	137±61

[1] Analyses for Al and Na for the PRS series are not available. Al and Na means for clusters are based on the MHK series only.

Assumptions for "greater than" and "less than" values received from laboratory: Al >100,000 = 150,000, Ag < 1 = 0.1, As < 5 = 0, Be < 2 = 0, Co < 5 = 1, La < 20 = 10, Mo < 5 = 0, Nb < 20 = 1, Sb < 100 = 1, Sc < 10 = 1, Sr < 100 = 20, and Y < 10 = 1.

It should be noted that only the data for U_3O_8, copper, arsenic, and lead were quantitative, the remainder being semiquantitative I.C.P. estimates. In addition, some of the deposit clusters are represented by only a few analyses. Also for the purpose of calculation, some rather arbitrary assumptions were made for analyses reported by the laboratory as "greater than" or "less than" (see footnote 2 to Table 82). Hence, the data must be interpreted with caution. Selected tentative observations are noted below, even though the use of means has given undue influence to single unusual values.

For Lithologic Groups

(1) U_3O_8: "Maroon" sandstones as a group are typically the richest and calcareous breccia the leanest.
(2) Cu and As: Apparent variation between lithologies is small.
(3) Pb: Sandstones as a group are typically the richest and siltstones plus shales the leanest.
(4) B: Siltstones plus shales are the richest and "maroon" sandstones the leanest, perhaps related to marine influence or the affinity of B for mica and clay minerals.
(5) Ca, Mn, and Sr: Calcareous breccias are distinctly higher.
(6) La: Calcareous breccias as a group are typically higher than other lithologies.
(7) Sb and Sc: Siltstones and shales may be enriched. Analytical verifications are recommended, however.
(8) Ti: The Ti contents appear to be surprisingly unaffected by host-rock lithology.
(9) V, Y, and Zr: "Maroon" sandstones may be slightly enriched.

For Clusters

(1) U_3O_8 and As have higher values in the McCauley 22 and "stratigraphically adjacent" clusters, and U_3O_8 is also high in the Old/New U.S. 220 cluster.
(2) B may be enriched in the Rock Run, Strawbridge, Sonestown Nose A, and North Mountain clusters.
(3) Ba is enriched in part of the Old/New U.S. 220 cluster.
(4) Mo is enriched in the Rock Run cluster.
(5) Ni may be depleted in the Sonestown Nose C cluster.
(6) V and Y may be enriched in the Sonestown Nose B cluster.

Medians

The medians of all analyses appear in Table 82, and provide a good estimate of typical mineralization in the project area. As a measure of central tendency, the medians are preferred to means because they are unaffected by a few atypical analyses. The medians tend to be much lower than the means of the ore elements because they are not unduly influenced by the few richest samples.

Medians for the semiquantitative trace-element analyses for each cluster are presented in Table 83. They provide the best estimate of the composition

Table 83. *Median Quantities of Trace Elements and Other Selected Elements for Clusters, Based on Semiquantitative Analyses*

Clusters are arranged by increasing elevation. Quantities are in parts per million unless otherwise indicated. See Table 9 for arsenic, copper, lead, and U_3O_8 medians.

Cluster name	Ag	Al[1] (%)	B	Ba	Be	Ca (%)	Co	Cr	Fe (%)	La	Mn (%)	Mo	Na[1] (%)	Nb	Ni	Sb	Sc	Sr	Ti (%)	V	Y	Zr
Rock Run	4	11.3	158	472	6	.28	33	96	3.4	30	.09	19	.7	1	52	1	12	20	.30	142	15	85
Fox Run Valley	14	7.0	58	352	2	1.2	20	90	2.0	50	.17	10	.1	1	32	1	1	20	.30	70	20	108
Strawbridge	6	5.3	110	310	3	1.3	24	72	2.3	40	.12	15	.9	1	40	1	1	20	.26	96	23	76
Beaver Lake	7	6.5	30	320	2	.63	19	64	2.0	50	.14	8	1.0	1	30	1	10	20	.30	82	26	102
McCauley 22	28	7.3	105	375	4	.14	28	98	3.0	32	.08	16	1.0	1	50	1	6	20	.32	155	24	105
Sonestown Nose A	3	---	150	595	4	.47	22	90	4.3	42	.13	10	---	10	46	1	15	20	.55	294	35	147
Muncy Valley	2	6.0	20	300	2	.70	15	50	1.5	50	.10	0	1.0	1	30	1	10	20	.30	70	30	200
Sonestown Nose B	2	5.8	44	308	2	1.5	24	70	1.9	50	.17	7	1.0	1	30	1	1	20	.30	232	36	125
Front	1	---	20	150	0	.10	20	10	1.5	50	.10	0	---	20	20	1	1	100	.50	70	20	150
Sonestown Nose C	7	4.0	10	300	0	.30	10	20	1.5	20	.07	0	1.0	1	15	1	1	20	.20	70	20	70
North Mountain	2	11.6	106	455	3	.47	25	74	2.8	36	.08	18	1.1	1	40	1	11	20	.30	252	18	74
Old/New U.S. 220	15	7.0	15	300	2	.31	33	50	2.0	50	.10	17	1.0	1	30	1	10	20	.30	220	50	110
Miscellaneous	.1	6.0	20	150	0	.70	15	70	1.5	50	.14	5	1.0	1	30	1	1	20	.30	70	20	15

[1] Analyses for Al and Na for the PRS series are not available. Al and Na medians for clusters are based on the MHK series only.

Assumptions for "greater than" and "less than" values received from laboratory: Al >100,000 = 150,000, Ag <1 = 0.1, As <5 = 0, Be <2 = 0, Co <5 = 1, La <20 = 10, Mo <5 = 0, Nb <20 = 1, Sb <100 = 1, Sc <10 = 1, Sr <100 = 20, and Y <10 = 1.

of mineralization in each cluster. Table 83 presents the cluster medians in order of increasing elevation, but for these elements, there are few apparent trends. Silver, probably following the trend for copper (Figure 11), is the only element that appears to show a relationship with elevation.

Conclusions from Statistical Studies

(1) In calcareous breccias, U_3O_8 follows As, Ag follows Cu, and Co may follow Pb and V.

(2) In sandstones, multiple processes may have occurred and partially overprinted or masked one another. The fact that Cu and U_3O_8 cannot be correlated also suggests separate processes. V and Co do not follow the "ore" elements. Ag follows Cu. Correlations between Zr-Ti and Y-U_3O_8 suggest that detrital heavy minerals may have been involved in mineralization and are not just inert hosts, as their typical stability would suggest.

(3) In siltstones plus shales, the samples from lower elevations resemble those to be expected from a restricted, black-shale environment, whereas the samples from higher elevations were influenced by detrital heavy minerals. The chemical composition of the original sedimentary host appears to have had a strong influence on the composition of mineralized lenses. Y follows U_3O_8 and possibly other "ore" elements. Cu and U_3O_8, As and U_3O_8, Cu and Ag, and As and Ag are sympathetic. Ni may have been removed as the intensity of mineralization increased.

(4) Pb tends to be most enriched in sandstones and least enriched in siltstones plus shales.

(5) "Maroon" sandstones may be enriched in V, Y, and Zr, as well as U_3O_8.

(6) Mean U_3O_8 data and mean As data for the clusters show bimodal distributions with elevation, similar to the distribution noted for medians (see "Genesis" section, p. 36).

(7) Mean U_3O_8 contents for the clusters, together with permeability and other considerations, tend to focus one's attention on the Old/New U.S. 220 cluster (505 ± 320 ppm U_3O_8).

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(Italic type indicates illustration)

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tyrolite: 1, *117*, 121, 122, 139, 226
tyuyamunite: 1, *118*, *119*, 121, 164
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uraninite: 1, 34, 111, *118*, 121, *122*, 124, 165
uranophane: 1, 35, 70, 79, 80, 111, *118*, 121, *122*, 177, 212, 226
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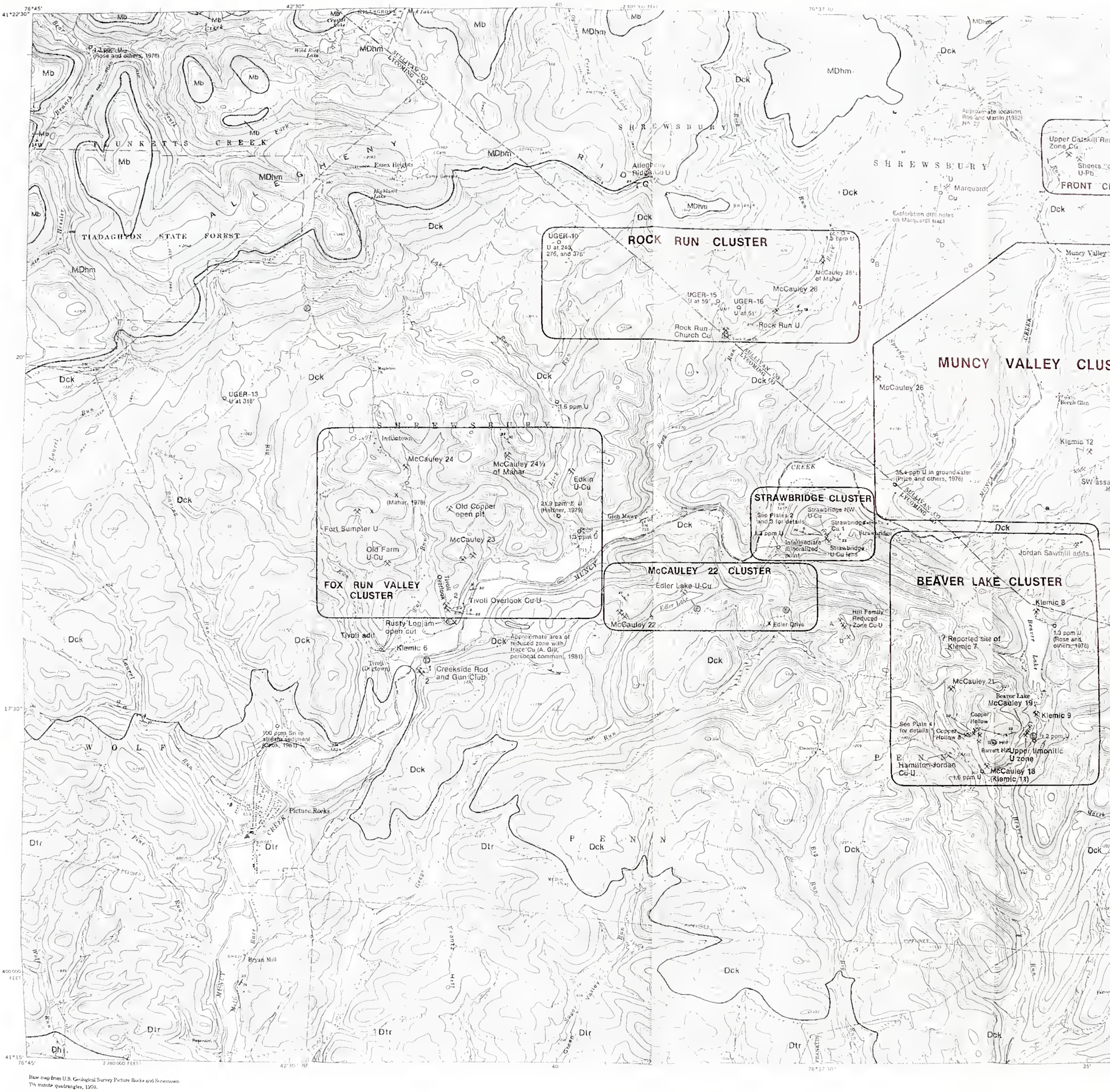
wulfenite: 1, 47, 212
Wyoming County, *see* Forkston
zeunerite: 1, 70, 86, 89, 111, 125, 149, 211

TOPOGRAPHIC AND GEOLOGIC SURVEY
Arthur A. Socolow, *State Geologist*

COMMONWEALTH OF PENNSYLVANIA
DEPARTMENT OF ENVIRONMENTAL RESOURCES



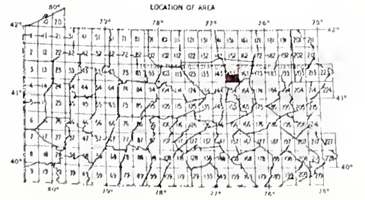
Base map from U.S. Geological Survey Picture Rocks and Sonestown 7½ minute quadrangles, 1970.

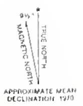
PLATE 1. LOCATIONS OF COPPER AND URANIUM OCCURRENCES IN THE PICTURE ROCKS AND SONESTOWN QUADRANGLES, LYCOMING AND SULLIVAN COUNTIES, PENNSYLVANIA

BY

ROBERT C. SMITH, II, AND DONALD T. HOFF

1983





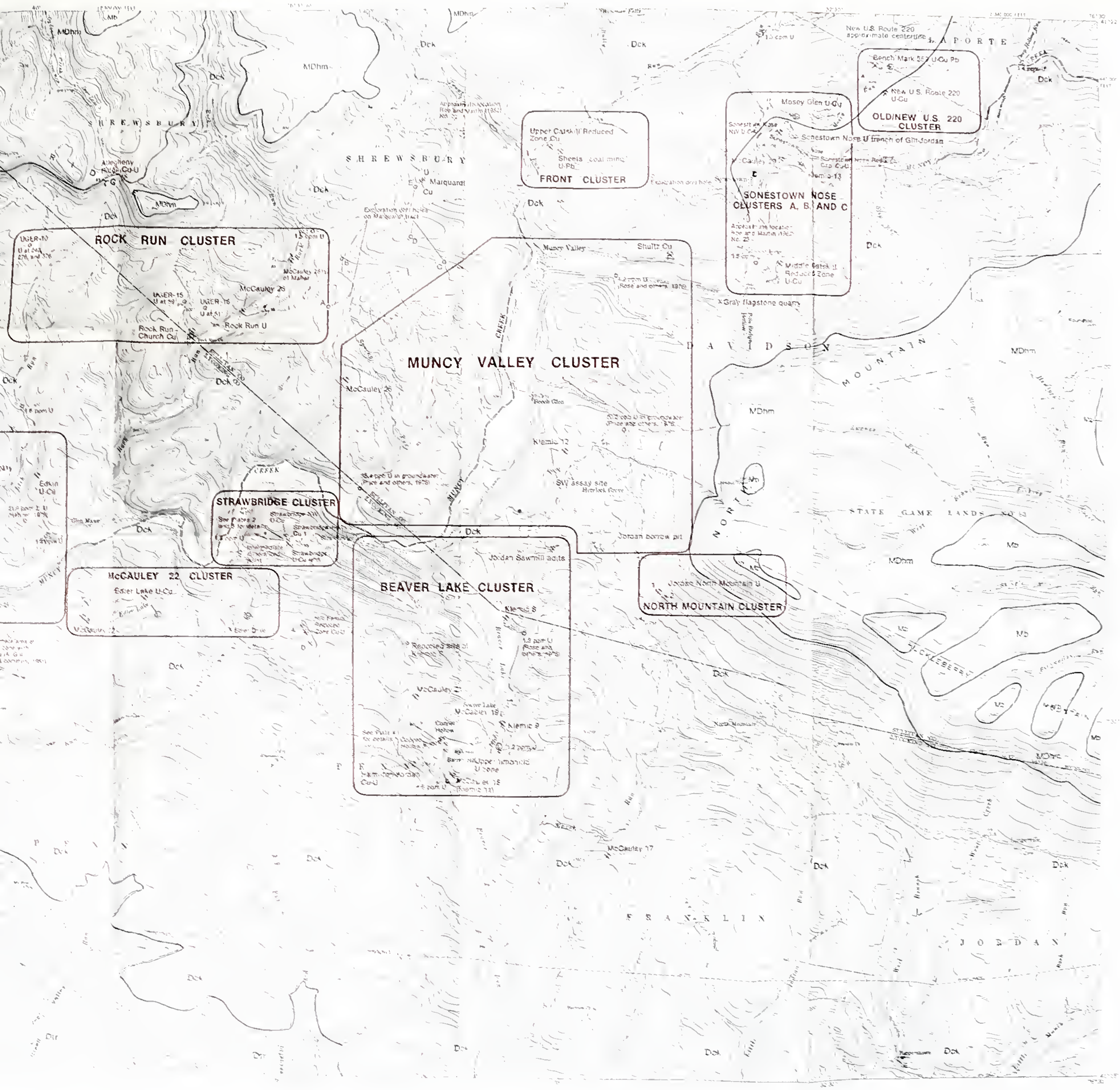
APPROXIMATE MEAN DECLINATION 1970

SCALE 1:24 000

CONTOUR INTERVAL 20 FEET
DATUM IS MEAN SEA LEVEL

COMMONWEALTH OF PENNSYLVANIA
DEPARTMENT OF ENVIRONMENTAL RESOURCES

M 86 Plate 1
PICTURE ROCKS-SONESTOWN



1. LOCATIONS OF COPPER AND URANIUM OCCURRENCES
HE PICTURE ROCKS AND SONESTOWN QUADRANGLES,
COMING AND SULLIVAN COUNTIES, PENNSYLVANIA

BY
ROBERT C. SMITH II, AND DONALD T. HOFF
1988

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James H. Dolimpio and Geary L. Sarno, Cartographers.

EXPLANATION

SYMBOLS

Location of copper and/or uranium occurrence or prospect described in text

Location of trace copper and/or uranium occurrence

Area where topographic base needs revision or correction

Location and depth of subsurface uranium mineralization found in exploration drill hole for which no other data are available

Location of exploration drill hole for which no data are available

1.5 ppm U — Acid- and H_2O_2-leachable uranium in stream sediment after correction for loss on ignition (Rose and others, 1976)

Strike and dip of bedding based on median of three measurements

Approximate strike and dip of bedding

Grouping of chemically related copper-uranium occurrences from a limited stratigraphic and areal range

GEOLOGIC UNITS

(Compiled by W. D. Sevon, 1977-78, based on aerial-photograph interpretation and reconnaissance field mapping by Sevon in the Picture Rocks quadrangle and Sevon and T. M. Berg in the Sonestown quadrangle)

Geologic contact. Approximately located.

Mb — Burgoon Sandstone
MDhm — Huntley Mountain Formation
Dck — Catskill Formation
Dtr — Trimmers Rock Formation
Dh — Hamilton Group

TOPOGRAPHIC AND GEOLOGIC SURVEY
Arthur A. Socolow, State Geologist

COMMONWEALTH OF PENNSYLVANIA
DEPARTMENT OF ENVIRONMENTAL RESOURCES

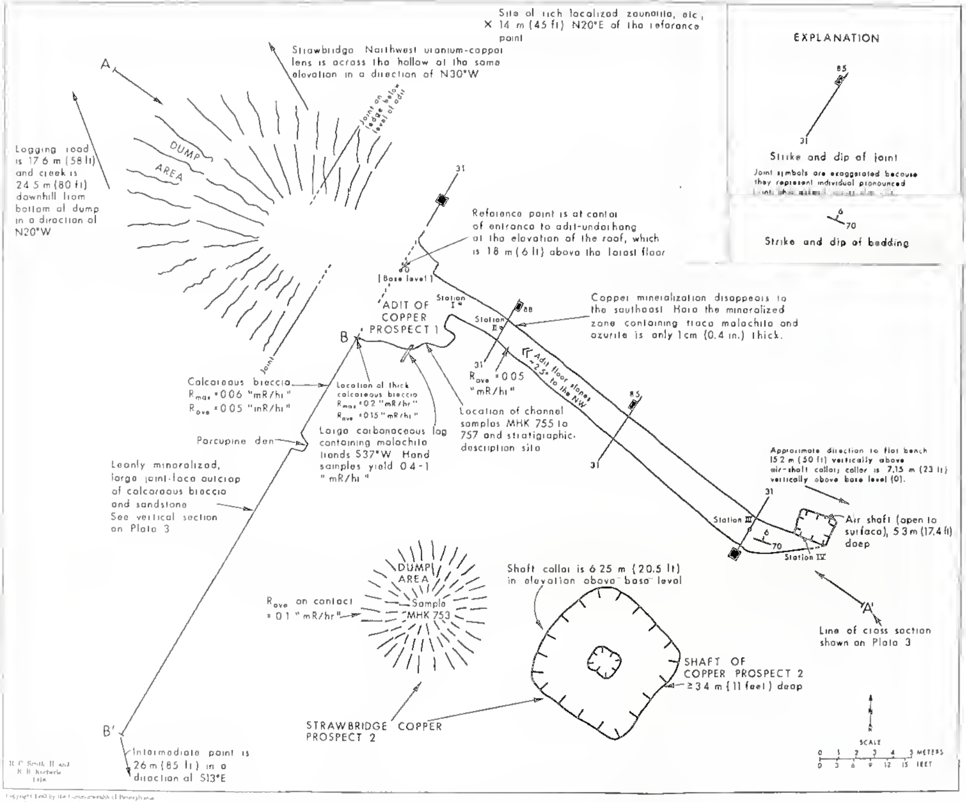
Site of rich localized zeunerite, etc., 14 m (45 ft) N20°E of the reference point
Strawbridge Northwest uranium-copper lens is across the hollow at the same elevation in a direction of N30°W
A
DUMP
AREA
Joint on ledge below level of adit
Logging road is 17.6 m (58 ft) and creek is 24.5 m (80 ft) downhill from bottom of dump in a direction of N20°W
EXPLANATION
85
31
Strike and dip of joint
Joint symbols are exaggerated because they represent individual pronounced joints that extend [illegible]
6
70
Strike and dip of bedding
31
Reference point is at center of entrance to adit-underhang at the elevation of the roof, which is 1.8 m (6 ft) above the lowest floor
0
(Base level)
Station I
ADIT OF COPPER PROSPECT 1
88
Station II
Copper mineralization disappears to the southeast. Here the mineralized zone containing trace malachite and azurite is only 1 cm (0.4 in.) thick.
B
Joint
31
R_{ave} = 0.05 "mR/hr"
Adit floor slopes ~2.5° to the NW
Calcareous breccia R_{max} = 0.06 "mR/hr" R_{ave} = 0.05 "mR/hr"
Location of thick calcareous breccia R_{max} = 0.2 "mR/hr" R_{ave} = 0.15 "mR/hr"
Large carbonaceous log containing malachite trends S37°W. Hand samples yield 0.4-1 "mR/hr"
Location of channel samples MHK 755 to 757 and stratigraphic-description site
85
31
Porcupine den
Leanly mineralized, large joint-face outcrop of calcareous breccia and sandstone. See vertical section on Plate 3
Approximate direction to flat bench 15.2 m (50 ft) vertically above air-shaft collar; collar is 7.15 m (23 ft) vertically above base level (0).
31
Station III
6
70
Air shaft (open to surface), 5.3 m (17.4 ft) deep
Station IV
A'
Line of cross section shown on Plate 3
DUMP AREA
Sample MHK 753
R_{ave} on contact = 0.1 "mR/hr"
Shaft collar is 6.25 m (20.5 ft) in elevation above base level
SHAFT OF COPPER PROSPECT 2 ≥3.4 m (11 feet) deep
STRAWBRIDGE COPPER PROSPECT 2
B'
Intermediate point is 26 m (85 ft) in a direction of S13°E
N
SCALE
0 1 2 3 4 5 METERS
0 3 6 9 12 15 FEET
R. C. Smith, II and R. B. [illegible]
[illegible]

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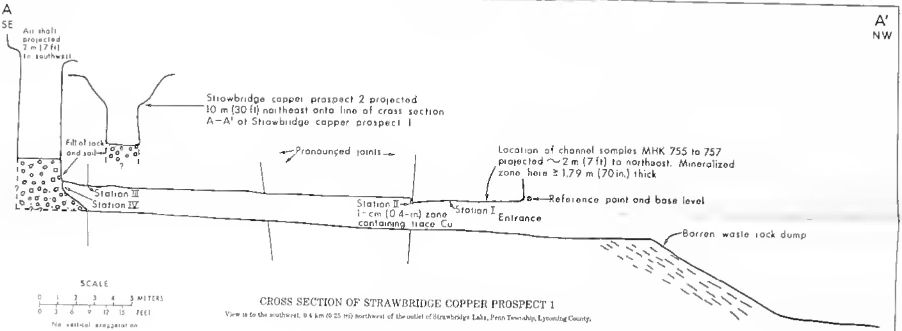
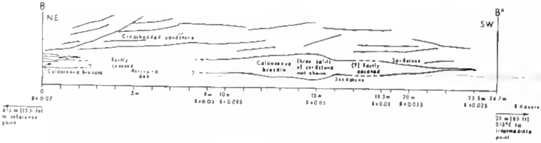
PLATE 2. PLAN MAP OF STRAWBRIDGE COPPER PROSPECTS 1 AND 2

Prospects are 0.4 km (0.25 mi) northwest of the outlet of Strawbridge Lake, Penn Township, Lycoming County.


A
SE
A'
NW
Air shaft projected 2 m (7 ft) to southwest
Strawbridge copper prospect 2 projected 10 m (30 ft) northeast onto line of cross section A–A' of Strawbridge copper prospect 1
Fill of rock and soil
Pronounced joints
Location of channel samples MHK 755 to 757 projected ~2 m (7 ft) to northeast. Mineralized zone here ≥ 1.79 m (70 in.) thick
Reference point and base level
Station III
Station IV
Station II
1-cm (0.4-in) zone containing trace Cu
Station I
Entrance
Barren waste rock dump
SCALE
0 1 2 3 4 5 METERS
0 3 6 9 12 15 FEET
No vertical exaggeration

CROSS SECTION OF STRAWBRIDGE COPPER PROSPECT 1

View is to the southwest, 0.4 km (0.25 mi) northwest of the outlet of Strawbridge Lake, Penn Township, Lycoming County.



SCHEMATIC DRAWING OF STRAWBRIDGE COPPER PROSPECT 1

Drawing shows calcareous breccia and gray sandstone exposed by a vertical joint 4.15 to 28.85 m (13.6 to 95 ft) southwest of the reference point, 0.4 km (0.25 mi) northwest of the outlet of Strawbridge Lake, Penn Township, Lycoming County. Section trends approximately N30°E, looking southeast.

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PLATE 3. CROSS SECTION (A-A') AND SCHEMATIC DRAWING (B-B') OF STRAWBRIDGE COPPER PROSPECT 1

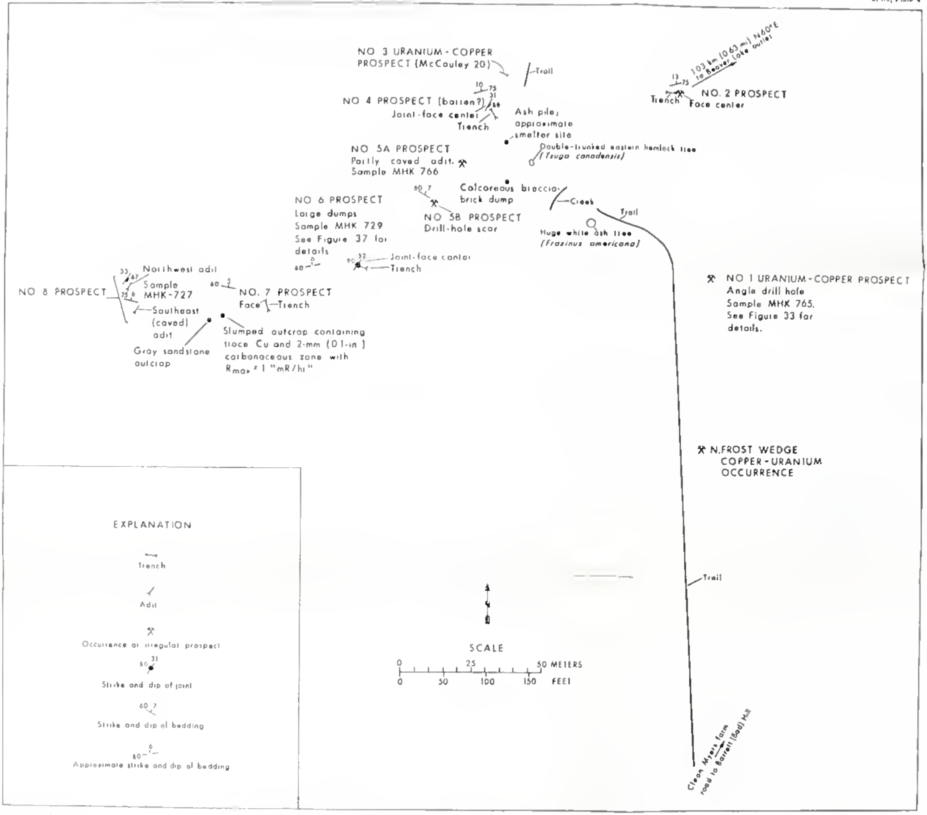
NO 3 URANIUM-COPPER PROSPECT (McCauley 20)
Trail
10
75
31
NO 4 PROSPECT (barren?)
Joint-face center
Trench
Ash pile; approximate smelter site
13
75
103 km (0.63 mi) N60°E to Beaver Lake outlet
Trench
NO. 2 PROSPECT
Face center
NO 5A PROSPECT
Partly caved adit.
Sample MHK 766
Double-trunked eastern hemlock tree (Tsuga canadensis)
60
7
Calcareous breccia-brick dump
Creek
Trail
NO 6 PROSPECT
Large dumps
Sample MHK 729
See Figure 37 for details
NO 5B PROSPECT
Drill-hole scar
Huge white ash tree (Fraxinus americana)
6
60
90
37
Joint-face center
Trench
33
67
Northwest adit
Sample MHK-727
NO 8 PROSPECT
75
6
60
5
NO. 7 PROSPECT
Face
Trench
Southeast (caved) adit
Gray sandstone outcrop
Slumped outcrop containing trace Cu and 2-mm (0.1-in.) carbonaceous zone with R_{max} = 1 "mR/hr"
NO 1 URANIUM-COPPER PROSPECT
Angle drill hole
Sample MHK 765.
See Figure 33 for details.
N.FROST WEDGE COPPER-URANIUM OCCURRENCE
Trail
Cleon Myers farm road to Barrett (Bod) Hill
N
SCALE
0
25
50 METERS
0
50
100
150
FEET
EXPLANATION
Trench
Adit
Occurrence or irregular prospect
60
31
Strike and dip of joint
60
7
Strike and dip of bedding
6
60
Approximate strike and dip of bedding

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PLATE 4. PLAN MAP OF COPPER HOLLOW

Copper Hollow is on the Cleon Myers farm, approximately 1.1 km (0.68 mi) southwest of the outlet of Beaver Lake, Penn Township, Lycoming County.